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## LUCERNE BREEDING TECHNIQUE. A NEW SYSTEM OF CLOSE BREEDING.

R. E. P. DWYER

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THE methods employed in the breeding of lucerne at Bathurst Experiment Farm prior to 1930 have already been described (3). Recent work at Bathurst has shown that honey-bees are important agents in tripping the lucerne flowers and thereby in assisting the setting of seed (5). The application of this to breeding technique has been described in this journal (6). It was shown that under conditions prevailing at Bathurst, honey-bees caged with several plants of a clonal family materially increased the production of selfed or sibbed seeds as compared with that from the same family caged without bees. Artificial tripping of the flowers is tedious and unreliable ; the increased production of selfed seed where bees are used considerably facilitates the breeding programme and obviates many difficulties in the isolation of strains for seed multiplication. It was also found that where one clonal family was given the opportunity to interpollinate with other clonal families by enclosure in a cage with bees, the number of seeds set per pod was nearly four times that obtained when plants of the *same* clone were encaged with bees and where self or sib pollination could take place. This fact illustrates the role of bees as important natural agents in the pollination or cross-pollination of lucerne (4).

Megee and Kelty (15), working at Ostrander, Michigan, in 1931, compared the seed setting of lucerne plants caged with and without bees. In these controlled tests the activity of honey-bees produced an enormous increase in both pod and seed setting.

The importance of honey-bees in the pollination of lucerne has clearly indicated their value in controlled lucerne breeding, and has led to the adoption of new methods of lucerne improvement at Bathurst Experiment Farm.

### SELF- AND CROSS-POLLINATION IN RELATION TO VIGOUR AND FERTILITY.

A review of the behaviour of lucerne plants as affected by self- and cross-pollination is presented as an introduction to this article.

Lucerne is known to be liable to natural self-pollination, although natural cross-pollination occurs to a greater or less extent. As indicated in a previous article (4), the amount of natural cross-pollination which occurs is still a matter for conjecture, and the data available are comparatively meagre. Investigators generally have found that cross-pollination either by different individual plants of the same variety or of a different variety is more effective than self-pollination in increasing seed setting. Piper and others (16) record a decided increase in favour of crossing, although good seed settings may be obtained where the natural agencies of cross-pollination are scarce. Carlson (1) agrees with this statement, and quotes Frandsen's record of a gain of 246 per cent in the average number of seeds formed per pod in cross-fertilized as compared with self-fertilized flowers. Torsell (18) observed a 20 to 50 per cent increase in seed set from crossed flowers as compared with self-fertilized flowers. Williams (19) found a 12·4 per cent decrease in the seed yield in the first generation of selfed plants.

The experience at Bathurst with honey-bees in relation to seed setting, where increased numbers of seeds per pod were obtained when caged bees were used as natural agents for cross-pollination, have served further to confirm these findings. In discussing the effect of self-fertilization and inbreeding in lucerne, it is generally conceded that inbreeding produces a loss in vigour and self-fertility, although opinions vary as to the amount involved.

From the work at Saskatchewan up to 1927, Kirk (11) found on the average a pronounced and progressive reduction of vigour and growth for each generation of selfing. With few exceptions, this was correlated with a marked decrease in seed yields as compared with open-pollinated strains. The same investigator stated in 1933 (13) that "inbreeding results in loss of vigour in nearly all species of herbage plants, which are normally cross-fertilized." Kirk also stated that "inbreeding in alfalfa is accompanied by a very marked reduction in self-fertility which is out of all proportion to the very considerable decrease in vegetative growth. This amounted to 70 per cent in the second generation, and in the fourth to almost complete self-sterility in a large proportion of the families." This conforms with the experiences of several other investigators not mentioned here. Torsell (18) showed that inbreeding gives a rapid and graded increase in self-sterility of lucerne in direct proportion to the number of years for which selfing has been employed. Thus, taking the fertility of each parent as 100, $F_1=35$, $F_2=27$ and $F_3=4$ ; with cross-pollination the fertility was greatly increased. Clarke and Fryer (2) observed that many lucerne plants produce high percentages of sterile pollen grains, which can probably be explained on the basis of East and Manglesdorf's conception of inhibiting factors (7). This pollen sterility lessens the chance of seed setting from self-fertilization, and emphasizes the importance of cross-pollination by insects and other agencies in the natural economy of the lucerne plant. Selfed line breeding has been conducted up to the fourth generation at Bathurst, and observations of the selfed progenies indicate a distinct loss of vigour after each generation of selfing.

This reduction of vigour due to self-pollination leads to many difficulties in lucerne breeding. Since lucerne is liable to self- as well as to cross-pollination, it is most probable that some self-pollination will occur and plants of low vigour will be produced where encaged honey-bees are used for cross-pollination of close or inbred strains. The proportion of self- to cross-pollination which occurs when honey-bees are encaged over lucerne plants of different types to provide facilities for maximum cross-pollination requires investigation. Until this position is cleared up, the effect on the breeding programme of a proportion of selfed plants, which may or may not be readily distinguishable and thus eliminated, cannot be estimated.

Some experiments not yet completed at Bathurst were designed to test the relative percentage of self- to cross-pollination brought about by the use of honey-bees under caged conditions. In one test a yellow-flowered hybrid lucerne plant and a purple-flowered lucerne plant, known to breed true for flower colour, were clonally separated into a large number of root divisions and planted in contiguous plots.

Representative plants of these will be enclosed under a single cage, and bees included to facilitate interpollination. The number of factors determining flower colour may upset the results to some extent, but, allowing for this, a close analysis of the flower colours present in the progeny from both clonal families should give a close approximation of the proportion of self- to cross-pollination occurring under such conditions. It is expected that a larger proportion of self-pollination will be present under seasonal conditions which do not favour pollen distribution by bees.

Any proportion of plants derived from selfed seed present in a single progeny which should be completely cross-pollinated by caged bees would upset the phenotypic uniformity of the progeny. To obviate this difficulty, any plants of low vigour derived from self-pollinated seed occurring in such a progeny could be rejected as comparing unfavourably with plants of normal hybrid vigour. In a progeny resulting

from seed where true recombination or crossing is essential to the success of the breeding programme, it may prove effective to cut or remove plants of low vigour, or at least to prevent them from flowering.

The marked increase in the content of lucerne seed pods obtained on a clonal strain when caged bees were used for interpollination in comparison with the set from plants of the same clone encaged with bees so that self- or sib-pollination alone could take place suggests a means of eliminating a large proportion of selfed seeds. The pods with most seeds usually contain a greater number of spirals. The seeds from the self-pollinated clonal family were generally more shrivelled than those to be expected from crossing, hence the passage of the seed through a sieve should further eliminate any seed resulting from self-pollination.

## METHODS OF BREEDING.

Improvement of lucerne may be done by the following methods :

(1) Introduction of strains and nationalities.
(2) Hybridization.
(3) Mass selection and strain building.
(4) Plant to row methods.
(5) Selection in self-fertilized lines and their recombination.
(6) Close and line breeding.

Some hundreds of varieties or nationalities of lucerne from all parts of the world have been introduced to Bathurst and other experiment farms in New South Wales, and compared with standard local strains. None of these have proved equal to local types, although introductions from countries with climatic conditions most nearly approaching those in New South Wales, such as Spain, Egypt and the Argentine, have proved most satisfactory. Natural or regional selection of the mixed populations of common lucerne first introduced has isolated the strains most suited to local conditions. The improvement of local types of lucerne is, therefore, the main objective of the work at Bathurst, while due attention is also paid to the isolation of strains with the best agronomic features.

## HYBRIDIZATION.

On account of the wide diversity of types present in most strains of lucerne, hybridization has not been used to any extent as a practical means of lucerne improvement. Kirk has crossed *Medicago sativa* with *M. lupulina* in order to combine the automatic tripping propensities of the latter with the agronomic qualities of the former. Material from this cross is under observation here ; it is of poor agronomic value for local conditions, although it may provide useful breeding material. *Medicago sativa* × *M. falcata* has yielded *M. media;* this is also under observation but is not promising. The possibility of crossing superior fodder types with Kirk's autogamous strains (12) or similar plants capable of automatic tripping which may be isolated in the future presents scope for further work.

The use of honey-bees in the large-scale cross-pollination of desirable strains is described in connexion with breeding methods in this article. Artificial cross-pollination is an accepted method in inheritance studies with lucerne.

A system which should be of particular use in lucerne breeding has been used in the improvement of tropical crops, such as coffee, which have pollination requirements similar to lucerne. Several selections are self-pollinated, and the progenies planted out as described for lucerne. Those which are most vigorous and of similar general type are then artificially cross-pollinated. Where the $F_1$ generation from this artificially crossed seed appears sufficiently promising, plants of the best original selections which most resemble each other (ecotypes) are grown together on a large scale to give maximum facilities for natural cross-pollination.

## MASS SELECTION.

Controlled mass selection as used in maize breeding has been practised to a limited extent with lucerne, although this should be a necessary prelude to most systems of lucerne breeding. In case the progress with other methods of lucerne improvement is not so successful as anticipated, a system of mass selection has been instituted at Bathurst.

Many plants were transplanted into carefully spaced rows from a seed bed sown with seed derived from local regional strains of lucerne. The best phenotypes or plants were then selected, and any inferior plants removed after observations for both summer and winter growth had been made. Open-pollinated seeds harvested separately from each of the selected single plants were included in the system of close breeding described later in this article. After elimination of the inferior types, a composite and mixed seed sample from all the selected plants was harvested and sown in a seed bed, care being taken to save sufficient seed for increase if desired. The resultant plants were again transplanted into rows as carefully placed single plants, and subjected to further selection as described for the previous generation.

This system of selection may be continued for many generations, but may have limitations as to the margin of increase gained in uniformity and yield. The amount of measurable improvement after each generation of selection is indicated in each case by a replicated progeny test of the remaining mass selected seed compared with ordinary bulk seed as a standard for comparison. Kirk (13) states "that mass selection properly employed offers a ready means of capitalizing on the work which nature has accomplished through natural selection over long periods of time."

## PLANT TO ROW METHODS.

Plant to row selection has not yet been introduced at Bathurst, but this method may be used with advantage in conjunction with mass selection.

## SELECTION IN SELF-FERTILIZED LINES.

This is recognized as being a genetically sound basis for breeding maize and other types of annual cross-pollinated plants, but its use in lucerne breeding is probably more restricted. Kirk (13) states that his "results with selfed line breeding with alfalfa up to and including the fourth generation of selfing have not been impressive as a practical method of improvement," and further that "if experience should show that maximum vigour can be restored and maintained under experimental conditions by selfed line breeding, it is altogether likely that other factors will be lost in the process ; factors which may influence profoundly the physiological response to the natural environment."

It appears from experience at Bathurst that there is no better method of surveying the breeding capabilities and the desirable and undesirable characters of a crop or variety than the selfing of numerous plants in the crop under survey for one or more generations and the observing of their progeny. This does not infer that it is necessarily the most practical method of lucerne improvement, but it is believed that this should be carried on in conjunction with any system of close breeding or strain building of lucerne. A judicious amount of selection from self-pollinated lines selfed for only one or two generations, and not carried on indefinitely until there is no clear basis for selection, should be very desirable especially as such selfed selections are capable of being used in systems of close breeding.

The experiences with honey-bees in assisting cross-pollination at Bathurst show that all methods of recombination of self-fertilized lines have not yet been sufficiently exploited to discard entirely this system of improvement. The evidence available at present is in favour of the adoption of other systems such as the close breeding

described later in this paper, but further research may show that the limitations of selfed line breeding of lucerne may not be so great as they appear at this stage.

The work of selection in self-fertilized lines was commenced at Bathurst by transplanting several thousand plants regularly spaced into a plot for detailed comparative observation. The first task was to secure self-fertilized seed from selected plants in these plots. Various methods were adopted to exclude insects and to ensure efficient self-pollination, such as bagging in different kinds of cages, bagging in glassine bags, selfing by means of isolation and by cutting back surrounding strains. Mechanical tripping of each flower head was adopted whenever caging or bagging was used, but now bees are employed under cages on the larger plots to ensure sufficient seed setting. The seeds obtained from each selfed single plant selection were sown separately into seed beds, and later transplanted as regularly spaced single plants into rows to allow for comparative observation and further selfing. Most of these lines have reached the third generation of selfing, while a few odd lines have been selfed four times. In the first and second generations, wide variations in vigour and uniformity were apparent in a number of the progenies observed. It thus appeared that some plants were more subject than others to crossing in the generations preceding selfing. Few of the selfed strains grown were completely uniform, although they showed a distinct similarity in general type. This indicates the prevalence of cross-pollination in the fields from which these strains were derived. It became increasingly difficult to obtain selfed seed from most lines after the second generation of selfing. Some of these selfed strains, on the other hand, have shown a surprising degree of uniformity, even after the first generation of selfing. The increasing uniformity coincident with continued self-pollination conforms with the experience of Hadfield (**8**) in New Zealand, and Stewart (**17**) in Utah. The latter shows "that inbreeding in alfalfa establishes a high degree of homozygosity, which indicates a considerable amount of self-pollination in the generation immediately preceding artificial self-fertilization." If the strains under observation prove sufficiently vigorous, the basis for an improved strain is well within sight.

Many of the lines, however, show more or less marked variations ; the best plants are used for further selfing, and observations are made of the vigour and uniformity of their progeny. The fact that reduction in vigour is more marked in some lines than in others indicates two possibilities :

(*a*) That it is possible to isolate lines most liable to natural self-fertilization which, despite their homozygosity, show little loss of vigour on selfing.

The recent discovery of autogamous strains of alfalfa by Kirk and White (**12**) in Canada shows that self-fertilizing plants occur in which tripping of the flowers is not necessary for fertilization and the production of seed ; this is an encouraging prospect in lucerne breeding. It is now essential for the lucerne breeder to make a complete survey of all his material to see whether such autogamous strains exist, especially as these would not require the optimum physiological and environmental conditions for good seed setting demanded by lucerne in general.

(*b*) That lines may be isolated with an average yield so much superior to the unselected composite original variety that, despite loss of vigour, they will still outyield the original heterogenous population.

Experiences with this and other crops show that this is of rare occurrence.

If these two possibilities do not exist in the material under survey, methods of breeding (other than selection) in self-fertilized lines must be followed in lucerne improvement. The recombination of selfed strains of similar type (i.e. ecotypes) is one method which suggests itself as a further means of developing improved strains of lucerne. Recombination of several selfed lines can also be effected by cutting back the inferior lines and allowing only the better lines to cross naturally in the field.

A new method of line breeding developed at Illinois (9) in connexion with breeding better strains of canning corn should also prove invaluable to lucerne breeders. "This consists of crossing inbreds or hybrids with an inbred strain of known high prepotency. Theoretically the progeny are being inbred and should decrease in yield, but the actual experience with three successive back crosses to the same inbred line is that there has been no such expected decrease in yield. The uniformity of type and size remained as good, if not better, than the first generation hybrids, and it is believed that the progeny can be maintained by means of simple selection." The principle underlying this method of producing an improved strain is that a certain inbred line is highly prepotent for a large number of favourable growth factors. Some practical difficulty exists in isolating or finding such a line, which can only be discovered as the result of testing many different matings.

## CLOSE BREEDING.

This is a new method of lucerne breeding which has been adopted at Bathurst to overcome the difficulties associated with selection in self-fertilized lines. The reasoning applied by Macaulay (14) for close breeding with maize suggested the basis for the application of this system to lucerne, but some important modifications have been introduced. The method originated as a direct outcome of the recent work establishing the importance of honey-bees in seed setting (5 and 6). The caging of bees over strains of lucerne brings the pollination under better control than has yet been found possible with maize or other wind-pollinated crops.

The programme which has been commenced is outlined as follows (see Fig. 1). Two thousand plants were transplanted from seed-beds which had been sown with a local regional strain of lucerne seed which does best under Bathurst conditions, and which shows a wide diversity of morphological types. The best phenotypes were then selected and allowed to set seed, the remaining plants being cut back to prevent flowering. Open-pollinated seeds from each single plant selection were then sown in separate seed beds, although seed of these selections may be sown direct into separate blocks in the field if desired.

The population derived from each single plant was then transplanted into small square blocks in the field, suitably spaced for caging and contiguous to each other. The next step was the caging of these blocks ; relatively few cages are required for this purpose when used on successive plots at successive flowerings. The cages are constructed as follows : An iron framework twelve feet by twelve, and six feet in height is covered with wire gauze or cheesecloth fabric. These cages are designed to cover single plots in which rows of five plants are spaced three links apart on the square.

Honey-bees are employed to effect fertilization. A small hive of bees is placed under each cage just prior to blossoming, to assist tripping and to ensure sufficient pollination and seed-setting. The blocks enclosed under each cage are the product of a single mother plant ; thus under each cage only plants derived from open-pollinated seed of the same individual plant will be allowed to pollinate one another. This is the basis of close breeding. The seed of selected plants in each block constitutes the material for further close breeding and selection. The difficulties associated with the proportion of self- to cross-pollination under each cage is described earlier, but must be obviated as far as possible to ensure success with this method of close breeding.

Bulk seed from each block is also harvested separately and observed and tested for uniformity and yield in comparison with the original composite stock or commercial seed. If such close-bred strains are not superior to the original variety, it will still be possible to recombine them to obtain added vigour, cross-fertilization being effected with bees under cages.

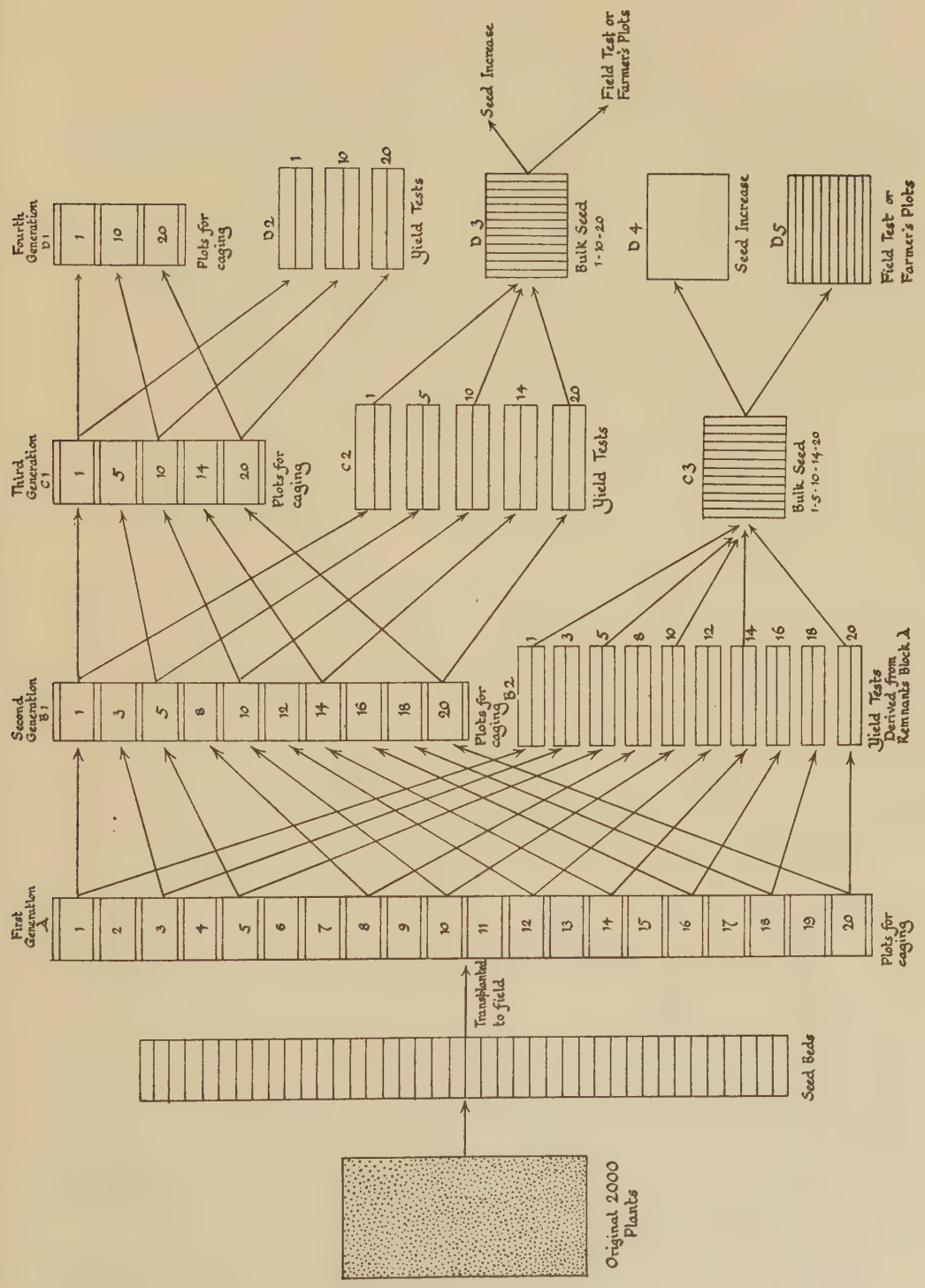


FIG. 1.—METHOD OF CLOSE BREEDING

It is considered that this system of close-breeding will permit the continuous elimination of inferior strains after each generation, until finally only the best strains as determined by performance in yield tests are perpetuated. This process of elimination does not preclude the building-up of bulk seed from the best strains at any time, without interfering with the programme of improvement. This is a type of "strain-building," a term coined by Jenkin (**10**) and also based on progeny testing. It is feasible to include strains (in this close-breeding programme) which have proved promising after one or more year's self-pollination, and so make good use of promising material already in the breeding plots.

The use of a system of close-breeding in lucerne is designed to obviate many difficulties associated with loss in vigour from continued self-pollination ; it seems possible that it will be unnecessary to wait for several years to obtain a strain of seed for multiplication and for distribution which will show a measurable improvement coincident with the progress made by each generation of further selection. It remains to be seen whether this method of lucerne breeding will obtain the desired results, although it is confidently expected that it will be a decided advance on previous methods. The author wishes to emphasize that at this stage the method described is in the nature of an experimental approach to the improvement of lucerne, and although future work may prove the procedure incorrect in some aspects, it has a sound basis for recommendation and trial on broad lines. The fundamental problems concerning the lucerne plant itself must be given more intensive study before the most practicable methods of lucerne breeding can be more clearly indicated.

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# GRASSLAND RESEARCH IN BELGIUM.

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A long visit of the writer to the Welsh Plant Breeding Station, in June to August, 1931, under the auspices of the "Nationaal Fonds voor Wetenschappelijk Onderzoek," preceded the foundation in September, 1932, of a State Plant Breeding Station connected with the State Agricultural College in Gent. In 1933 the necessary field space, and early in 1934 the necessary buildings and complete field equipment were available. This station, which was created to undertake the improvement of forage and industrial crops, gave particular attention to grasses and clovers, which had been quite neglected up to that time.

Nearly 42 per cent of the agricultural land in Belgium is under grass. (Table I.)

**Table 1.—Area of agricultural land under grass, according to latest census (1929).**

| Type of grassland | Actual area in Ha. | Percentage of total agricultural land |
|---|---|---|
| Permanent | | |
| Meadows .. | 237·136 | 11·86 |
| Pastures .. .. | 309·990 | 15·51 |
| Orchards .. | 66·248 | 3·31 |
| Temporary (including clovers) | 216·626 | 10·83 |
| Total .. .. .. | 830·000 | 41·51 |

With the limited means at our disposal, and inspired with the idea of benefiting our farmers, we attacked the problem of improving our grassland on the following lines:

(1) Botanical analysis of grassland.
(2) Nationality trials.
(3) Selection and breeding work.

## Botanical Analysis of Grassland.

A survey of the botanical composition of swards in different parts of the country appeared to be of value in obtaining knowledge of our agriculture. The first analysis of this kind in Belgium was made on the permanent grassland of the farm of the State Agricultural College. Subsequently we were very fortunate to receive financial help from the "Nationaal Fonds voor Wetenschappelijk Onderzoek," for similar analyses of pastures in Veurne, Ambacht, West Vlaamsche Polders, Dender–, Durme–, and Schelde–valleys. Results were published in: "Mededeelingen der Landbouwhoogeschool en der Opzoekingsstations van den Staat te Gent."

We found that as a general rule comparatively few of the commonly sown grass species play a really important part in the making of a sward, and that the importance of a particular species varies greatly from one pasture to the other. (Table 2.)

**Table 2.—Partial results of botanical analysis of grassland.**

| Type of soil | Grass Species | Minimum percentage | Maximum percentage |
|---|---|---|---|
| Sandy loam(1) | *Poa pratensis* .. | 48·37 | 62·04 |
| | *Lolium perenne* .. | 12·40 | 20·22 |
| | *Agrostis alba* .. .. | 6·35 | 13·46 |
| | *Holcus lanatus* .. | 0·80 | 12·70 |
| | *Trifolium repens* .. | 1·00 | 8·92 |
| | Weeds .. .. | 1·37 | 28·99 |
| Clay (2) | *Lolium perenne* .. | 64·30 | 84·50 |
| | *Agrostis alba* .. | 2·00 | 3·60 |
| | *Poa pratensis* .. | 0·40 | 21·30 |
| | *Trifolium repens* .. | 7·80 | 13·20 |

In both soils about 97·50 per cent of the sward is composed of the named species.
(1) Melle (near Gent). Grassland mainly grazed. Used for hay once in 5 to 6 years.
(2) Veurne–Ambacht. Grassland exclusively grazed.

We are now planning a more complete survey to cover all the important grassland sections of the country, in order to obtain a more accurate picture of our grassland problems. We do not yet know the relative value of our grassland, and consequently we are unable to make a concrete statement at this time as to its improvement on a large scale. We have dealt with permanent pastures containing from 66 to 88 per cent of weeds, pastures which were considered by the owners to be of fairly good quality.

## Nationality Trials.

Practically speaking, we still depend entirely on imported grass and clover seeds for the establishment of new grassland. The necessity of collecting facts to demonstrate to our farmers the importance of the source of seed was only too obvious. We established the first nationality trial in 1932 on a plot belonging to the farm of the State Agricultural College. Similar trials were laid out in the three subsequent years. These show differences in yield, both under hay and pasture conditions, for the various grass and clover species involved, and very often similar differences for various sources of seed of a particular species. Differences in longevity and in wintergrowth also become apparent.

## Selection and Breeding Work.

We are particularly interested in *Lolium perenne*, *Phleum pratense*, *Dactylis glomerata*, *Festuca pratensis*, *Trifolium repens* and *Trifolium pratense*.

Up to the present we have concentrated upon *Lolium perenne*. Generally speaking, we are aiming at the production of leafy, long-lived strains with a good tillering capacity.

Our indigenous material of *Lolium perenne* shows an average leaf : stem ratio of between 27 and 41 per cent in the first hay cut as compared with an average leaf : stem ratio of 30 per cent for Danish Commercial (as check) under the same conditions. A fairly good idea of the stemminess of the aftermath may be had from Table 3.

**Table 3.—Number of flowering periods for different sources of Lolium perenne.**

| Experiment Number | Source of Seed or Tillers | Average percentage of plants with | | |
|---|---|---|---|---|
| | | 2nd flowering period | 3rd flowering period | 4th flowering period |
| P.4 | Commercial | | | |
| | Different sources | 96·10 | 28·00 | 2·00 |
| | Improved foreign | 40·60 | 1·60 | — |
| P.12 | Danish commercial | 83·00 | 6·00 | — |
| | Indigenous .. | 4·25 | — | — |
| P.3 | Indigenous .. | 0·50 | — | — |
| | Indigenous .. | — | — | — |

The average number of non-flowering tillers in our indigenous *Lolium perenne* varies between 13 and 80 per plant, as compared with an average of 16 per plant in Danish Commercial. The total tillering capacity expressed as an average of all tillers, flowering and non-flowering, showed that the Danish had 146 and our indigenous material 66 to 394 tillers per plant.

During the last season we collected open-pollinated seeds on various promising plants of the above-named grasses with a view to establishing strains. We also started inbreeding experiments with the same grasses. White and red clover work will be taken up intensively this coming season ; we have already collected promising white clover material.

Finally, we expect to devote more time to advisory work. We are quite convinced of the necessity of establishing a close contact with our farmers. It is, in fact, the only means of learning about their unsolved problems, which must be numerous. We have already had occasion to advise regarding the use of simple seeds mixtures, which the farmers report have given much better results than the commercial mixtures used previously.

The different aspects of grassland management are still an untouched field for research. Grazing, manuring and rejuvenation are among the many interesting problems which it will be necessary to solve in the near future.

# NOTES ON THE SAMPLING OF SOIL TO DETERMINE THE CONTENT OF BURIED SEEDS.

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In correlation with the improvement and renovation of grassland it has been found desirable to obtain some knowledge of the seeds contained in the soil underlying pastures of different kinds. For this purpose two separate procedures have been adopted, the first being necessary where information is required on the spatial distribution of the seeds in the soil, and the second being suited to providing general knowledge of the buried seed flora present over wide areas or in a large number of separate places.

(i) Throughout the district which has been under study (i.e. Cardiganshire) the soils are generally so filled with stones as not to allow of sampling with any large instrument cutting out a block of definite size and shape, and a somewhat elaborate technique has therefore been employed. Four trenches are cut so as to isolate a column of soil of about 9 in. square in cross-section (and hence also in surface area), and as nearly 14 in. deep as is possible in each particular case. The column is then cut through at the base, removed in its entirety and inverted, so that it rests on the surface vegetation; the first two inches of soil which are now uppermost (i.e. the lowest soil when *in situ*) are removed and discarded, together with parings taken from the four sides of the block. The soil is now removed horizontally in successive inches of depth, and each separate inch placed in a paper envelope, these operations being performed throughout with considerable care so as to minimize the possibility of one sample contaminating another. Subsequently, at a convenient time, the samples are crumbled by hand, any stones they may contain removed, and a measured amount of each (roughly 36 cubic inches) placed in clean boxes in unheated glasshouses; it is advisable to have about 1 in. depth of clean soil beneath the soil, which from this time is kept in a condition suitable for the germination of any seeds it may contain. It has been usual to take four blocks from each area which, by having a uniform vegetation, could be treated as a single example.

The seedlings which develop in the soil samples are removed immediately it becomes possible to identify them, and none in any case allowed to produce seeds. The entrance of wind-carried seeds into the glasshouses is prevented by covering the ventilators with muslin, and all water given to the samples is first passed through a filter. Numerous control boxes of sterilized soil are also exposed among the samples, so that an estimate is obtained of the effectiveness of these precautions against external contamination.

(ii) The results obtained from the use of the preceding method have shown that the great majority of the seeds in the soil occur within six inches of the surface; for surveys on an extended scale, therefore, samples of soil have not been taken at depths much greater than this. Such samples are easily obtained by the removal first of a disc of turf 2½ in. in diameter and 1 in. in depth, and afterwards of a narrow cylinder of soil about 6 in. deep. For the latter operation a thistle-eradicator is used. This instrument consists of a wooden handle carrying a steel trough, 1¼ in. in width and 7 in. in length, having a cutting edge at its lower extremity and two projecting curved teeth on one side; a projection at the top of the trough and at right-angles to it assists in forcing the instrument into the ground.

The samples obtained with the eradicator from any unit area are put together, as is also the soil from the samples of turf after the living portions of the latter have been removed. In both cases the soil is set out in the manner described for method (i), so that from each area two sets of boxes are maintained, namely, those containing soil from the top inch of the pasture and those boring the soil which underlay this to some 6 in. From each unit area fifty samples are taken in random fashion; in consequence, however, of variation in the degree of coherence in soils of different texture, the total volume of soil obtained is not constant for each area.

# REVIEWS

## THE VEGETATION FACTOR IN EROSION CONTROL.*

THE President of the United States said in a message to Congress : "Many million acres must be restored to grass or trees if we are to prevent a new man-made Sahara." The stripping of land of its rich surface covering and its further depletion by gullying as the result of unrestrained erosion by wind and water, following careless, haphazard methods of land use, are the agencies which are creating these new and large areas of essential desert, and which have brought the United States face to face with a crisis in land utilization.

Much of the sub-humid Great Plains, originally splendid grazing country, must eventually go back to grass, just as countless steeply sloping areas of the more humid regions must be taken out of cultivation and stabilized with trees, grass, or other thick-growing crops that will hold the soil in place.

### THE SOIL CONSERVATION SERVICE.

The Soil Erosion Service was established in September, 1933, under the office of the Secretary of the Interior, to administer a grant made by the Federal Emergency Administration of Public Works for erosion control activities. In April, 1935, this Bureau was transferred to the Department of Agriculture, renamed the Soil Conservation Service and placed under the direction of H. H. Bennett. In this new bureau were concentrated all activities of the Federal Government in erosion control on agricultural lands.

Included in the programme of this Service are the investigations and research into the character of soil erosion and methods of control in progress at twelve regional erosion experiment stations. Field work of demonstrations is in progress on forty erosion-control projects in representative watersheds in the major geographical and agricultural regions. Thirty-seven of these projects are essentially demonstrational and involve private lands. The remaining three are complete land-rehabilitation projects covering an aggregate area of 35,700,000 acres in highly-erodible South-West, most of which is on land owned by the Federal Government. These projects involve sixteen million acres on the Navajo Indian Reservation in Arizona and New Mexico, over eight million acres on the watershed of the Gila River in the same States, and eleven and a half million acres on the watershed of the Rio Grande in New Mexico.

Space does not permit of the further discussion of the organization and general location of the work of the Service. Readers particularly interested should refer to the paper read by Dr. W. C. Lowdermilk at the Third International Congress of Soil Science, Oxford, 1935.

The remainder of this review is concerned with the vegetation factor as exemplified by the crops or pastures grown on the land. No attempt is made to deal with the forestry aspect. This and other aspects have been covered by R. Maclagan Gorrie (8).

*For the information and literature upon which this review has been based the Herbage Bureau is indebted to its American correspondent (C. R. Enlow) and to other members of the staff of the Soil Conservation Service of the U.S. Department of Agriculture [H. H. Bennett (Director), R. V. Allison, etc.].

## COMPARATIVE LOSSES.

The role of vegetation in the control of soil and water losses has been amply demonstrated in a number of ways under controlled conditions at the erosion stations. The results most commonly referred to in this connexion are those from the control plots. A brief review of these studies at the Red Plains Soil Erosion Station, Guthrie, Oklahoma, covering the four-year period 1930–33 (average rainfall: control plots = 32·92 ins.; woods plots = 33·49 ins.; soil = Vernon fine sandy loam) will suffice as a general illustration of the trend of the relation which is found to be similar at all stations. In Table 1 the cultivated crop or plots are grouped for convenience. The value of vegetation for the control of soil and water losses is readily apparent

**Table 1. Relation of Type of Vegetation to Run-off and Erosion.**

| Crop and/or treatment | Slope | No. of plot years | Run-off | Erosion |
|---|---|---|---|---|
| | | | per cent | tons per acre |
| Cultivated crop (cotton) .. .. .. .. | 7·7 | 16 | 14·0 | 26·7 |
| Small grain (wheat grown in rotation) .. .. | 7·7 | 4 | 13·2 | 1·8 |
| Hay (sweet clover grown in rotation) .. .. | 7·7 | 4 | 9·2 | ·72 |
| Woods (burned off) .. .. .. .. .. | 5·2 | 4 | 5·1 | ·22 |
| Bermuda grass sward (*Cynodon dactylon*) .. | 7·7 | 4 | 1·5 | ·04 |
| Woods (virgin) .. .. .. .. .. | 5·2 | 4 | ·14 | ·02 |

*Note.*—These plots established as strips 6 feet wide and 72·6 feet long on the slopes indicated in such a way that all soil and water losses are caught at the base of the lower end and accurately measured.

from these figures. Thus, the cultivated plots have lost about 50 per cent more rainfall and 37 times as much soil in comparison with the sweet clover cover, and 84 per cent more rainfall and 667 times more soil in comparison with the grass plot. While the general control plots are not to be compared directly with the wood plots on account of differences in slope, it is found that the undisturbed woods cover is very effective indeed in this relation and probably about as efficient as the grass cover under the same conditions of exposure.

A similar example can be given from measurements made at the Bethany Erosion Station, Missouri, situated on one of the most extensive soils in the rolling sections of the corn belt. From the average regional slope (8 per cent) the annual soil loss from a representative cross-section of a strip 73 ft. wide has amounted to approximately 60 tons per acre, together with a loss of 27 per cent of the total precipitation where maize is grown continuously. The corresponding losses from areas devoted to thick-growing crops under exactly the same conditions of soil, slope and rainfall were very much less. Under alfalfa there has been a loss of only 0·2 ton of soil per acre annually, with a run-off of only a little over 3 per cent of the precipitation; under timothy only 0·3 ton of soil and about 8 per cent of the precipitation have been lost.

## ORGANIC MATTER.

The results of work at some of the stations also show that the action of organic matter in the soil upon the control of soil and water losses is distinctly significant. While this effect sometimes appears as secondary in the form of improved plant

growth and the consequent use of water which its presence promotes, there is evidence in studies on the Marshall soils at Clarinda, Iowa, that its effect may also be direct as observed under fallow conditions.

### STRIP CROPPING.

The commonest form in which attempt is being made to use the vegetation factor systematically under regular field conditions is through what is usually referred to as strip cropping. This involves the laying out of strips of definite width along the contour for alternate use of cultivated and close-growing or filter crops. The width of the strips and consequently the proportion of the area that can be devoted to cultivated and protective crops respectively will depend naturally not only on the soil involved, but also on the degree and regularity of the slope, the extent to which the area has already been washed or gullied, and the care that will be given to their establishment, cultivation, and maintenance. Where permanent strips are planned, contour back-furrowing for a couple of years is useful in providing a permanent guide.

**Table 2. Approximate width of strips in relation to degree of slope.**

| Slope of land | Width of cultivated strip | Width of buffer crop strip |
|---|---|---|
| 0 to 2 per cent | Up to 100 feet | 20 to 30 feet |
| 2 to 4 ,, ,, | Not more than 75 feet | 30 to 40 ,, |
| 4 to 6 ,, ,, | 40 to 50 feet wide | 40 to 50 ,, |
| *6 up to 8 ,, ,, | 30 to 40 feet wide | 50 to 60 ,, |

* Land with 6 to 8 per cent slope erodes very easily, and as much of it as possible should be kept in permanent vegetative cover.

With reference to width of strips Table 2 indicates the schedule of slope relations prepared for the Redlands area of the south-west by the Guthrie workers. It is apparent that as the slope increases so must the width of the protective strip increase at the expense of the area available for the cultivated crop. It is also apparent that this may be varied in either direction for other soils, according as to whether they are more or less pervious to the absorption of surface water. In the Tyler area, Texas, considerable emphasis is being placed on rather narrower strips that centre around balk strips which are seeded to vetch or other close-growing crops and broken out at the proper time to form drainage furrows which lead to natural protected drainage ways somewhere along the slope.

Points of particular importance are of course that :

(*a*) the strips be laid out carefully on the contour or deviate from the contour only to a definitely controlled degree according to conditions of soil or topography ;

(*b*) all operations on the cultivated areas are carefully contoured with the strip and as much basin capacity developed by this procedure as possible ;

(*c*) short or point rows be avoided as far as is desirable or necessary by taking up the irregularities developed between the strips with the closely-seeded crop which naturally can take almost any form without much inconvenience in field operations.

At Bethany it has been found very convenient and desirable to seed the irregular tops and bases of the slopes with thick-growing crops such as alfalfa or mixtures of clover and timothy which can occupy such areas without being disturbed for several seasons, if desired.

With care in laying out the strips, in adjusting the crop rotation to them, and in cultivating properly at all times, the most important point remaining is the permanent grassing over of the natural drainage ways.

A recent review of the possibilities of strip cropping in a number of the areas indicates good expectations for practical erosion control on slopes up to 8 or 10 per cent, although this will vary considerably from soil to soil and worker to worker.

### GULLY CONTROL.

The important role of vegetation in gully control, whether as an accompaniment to strip cropping or upon its own merit in independent washes, is coming to be recognized very generally. Naturally, work in the gully would be protected as far as possible by the diversion of its natural drainage waters at least during the period of healing. The wide range of conditions to be considered under this head makes a brief discussion of the subject impossible. It has been fully demonstrated that vegetation is extremely effective in slowing down and even stopping washes of this nature under practically any conditions. Once vegetation is established for this purpose it must be fully protected against overgrazing or other injury.

### CROP ROTATIONS.

The development of a proper rotation in a particular area is an important matter, whether it be for use in strip crop work or for ordinary field practice. The particular point is the manner in which the cultivated crops are introduced. Some studies have shown that the amount of erosion produced by cultivated crops such as corn or cotton in a one-crop system is much more severe than where they appear in a well-ordered rotation. The reasons for this are as obvious as the results are striking; cultivated crops should be followed by close-growing covers, or, the soil should be protected through the winter by temporary covers.

The approximate degree of exposure of the soil to erosion that follows the use of a given rotation has been calculated at the Bethany station. The calculated "protection" value is based entirely on soil losses for the various crops or the field operations that accompany them through the seasons. The setting up of such a schedule of information necessarily involves important elements of judgment. The total amount of protection credited to the three-year rotation of northern Missouri, maize, wheat and clover, is 80 per cent; percentage figures for other rotations are:

| | |
|---|---|
| Maize, oats, clover .. .. .. | (about) 80 |
| Maize, oats, wheat, clover .. .. .. | 74 |
| Maize, maize-oats, clover .. .. .. | 68 |
| Continuous maize .. .. .. .. | 27 |

It is suggested that similar figures for the rotations of other States should also be interesting, e.g.:

Three-year Wisconsin rotation of clover-maize-barley.

Four-year Iowa rotation of maize, maize, oats, clover.

Three-year Oklahoma rotation of (1) grain sorghum (followed by cowpeas turned under), (2) oats (followed by Sudan grass for hay), (3) cotton (followed by wheat cover).

Two-year Texas rotation of maize or cotton, with oats or vetch as a winter cover, followed by red top sorghum (for hay), alfalfa or lespedeza.

The data presented in Table 3 show the effect of some of these crop rotations on erosion and run-off for a number of important soil types. In every case crop rotations materially reduced the losses of soil, as compared with losses from similar land, with the same slope and the same rainfall, where a clean-tilled crop was grown; in all but one instance, the run-off from areas under continuous clean tillage was greater. The saving of soil ranged up to six times that where a one-crop system of

clean culture was practised, with a corresponding conservation of rainfall of nearly three times as much. The average saving over single-crop culture for the eight types amounted to 164 per cent of soil and 37 per cent of water.

**Table 3. Comparison of Soil- and Water-losses under Crop Rotations on Eight Important Soils.**

| Location | Soil | Slope | Rotation | Mean precipitation | Soil loss | Water loss |
|---|---|---|---|---|---|---|
| | | Per cent | | Inches | Tons per acre | Percentage of precipitation |
| Bethany, Missouri | Shelby silt-loam | 8 | Maize, wheat, clover | 34 | 10 | 11 |
| Columbia, Missouri | Shelby loam | 3·7 | Maize, wheat, clover | 40 | 10 | 24 |
| Hays, Kansas .. | Colby silt clay loam | 5 | Wheat, kafir sorghum, fallow | 22 | 10 | 16 |
| Guthrie, Oklahoma | Vernon fine sandy loam | 7·7 | Wheat, sweet clover, cotton | 33 | 6 | 12 |
| Temple, Texas .. | Houston black clay | 4 | Cotton, maize, oats | 27 | 6 | 5 |
| Tyler, Texas .. | Kirvin fine sandy loam | 8·75 | Cotton, maize, lespedeza | 42 | 16 | 18 |
| La Crosse, Wisconsin | Clinton silt clay loam | 16 | Barley, maize, clover | 29 | 21 | 13 |
| Statesville, North Carolina | Cecil sandy clay loam | | Maize, wheat, lespedeza, cotton | 43 | 7 | 10 |

## PASTURES AND GRASSLAND IN EROSION CONTROL.

Under all conditions vegetation plays an important part in preventing soils from being washed away ; of all types of vegetation, one group, the true grasses, is invaluable in stopping surface run-off. One result obtained at the Erosion Experiment Stations stands out above all others, and that is the fact that a grass sward will absorb a heavy downfall of rain. No other vegetative covering, unless it is an ungrazed unburned forest growth, is quite so effective. Land covered with clovers, alfalfa and other perennial plants may not lose much soil by erosion, but generally there is not such a complete absorption of water as in the case of grass. Water absorbed by the soil prevents floods and is an insurance against future droughts. This greater absorptive power of grassland is considered to be due to the minute openings left in the sward by decayed grass roots. The sod from a short-lived annual grass does not appear to be so effective as a permanent sod a few years old.

Injudicious grazing methods have caused an enormous waste of the natural grazing resources in the United States. Undergrazing in the eastern or humid portion of the country, in the humid regions along the Pacific Coast, and in irrigated pastures in other States has been an important cause of deterioration of pasture lands. In the drier regions, including the western range country, overgrazing has been the cause.

It is stated that a great improvement in the more humid regions might be expected from a spread of the English conception of pasture management, as typified by the experiments of D. B. Johnstone-Wallace at Cornell University, Ithaca. One result of this work will be a greater realization of the value of wild white clover in pastures. Further south from the Gulf of Mexico to the Potomac, *Lespedeza* is taking an important place.

### THE SEMI-ARID PLAINS.

Vegetation plays an important part in the erosion control programme in the Great Plains; its use may vary from the complete reforestation of the steep hill land to the adoption of cover crops in the general cropping or possibly the establishment of permanent pastures on abandoned crop land. Throughout the Great Plains the regrassing of abandoned farm land is one of the major problems of the Soil Conservation Service.

The Section of Nurseries is responsible for supplying all seed and planting material used in demonstration areas of the Soil Conservation Service. Nurseries for the production of trees and shrubs have been established at convenient places, while grass nurseries are distributed throughout the Great Plains States at Mandan, N.D., Lincoln, Nebr., Manhattan, Kansas, Stillwater, Oklahoma, Tucson, Ariz., Colorado Springs, Colo., and Pullman, Washington. The grass nurseries serve as centres where seed samples of different native and introduced species are grown and observed as to their economic value and suitability for erosion control. Promising species are being increased for use on demonstrational areas. The staff at these nurseries have also obtained data on the distribution of the different species. The vegetation charts are to be enlarged and details added with the final object of making a complete set giving the limits of each of the important species of grass in the Great Plains. This is the first thorough survey of the distribution of the native western grasses.

A conference of nurserymen, State Extension and Experiment Station workers, and agronomists representing the Soil Conservation Service projects in the Great Plains States was held at Colorado in May, 1935, to prepare plans for establishing grass cover on seriously eroded and abandoned areas. It was then concluded that the native grasses would have to be the basis for regrassing the abandoned areas, especially where these areas were in regions of extreme temperature and drought, and where the natural fertility level had decreased owing to severe erosion. Estimates compiled at this conference indicated that 25 native species, covering about 1,000,000 lb. of seed, would have to be collected to supply the 1935 requirements of the Soil Conservation Service. Since none of these species of grass had hitherto been handled in such large quantities, the question of organization of personnel and equipment was a difficult one.

Locating areas for harvesting seed, meeting Government regulations not written to cover such unusual and emergency situations, and perfecting machines for harvesting, threshing and cleaning the seed have presented almost insurmountable difficulties, but the splendid co-operation of all Soil Conservation Service personnel, as well as State authorities and others from various Government agencies, has made the 1935 collection programme a success. During this year about half a million pounds of seed of species that have not been on the market at any previous time, except in very small quantities, have been collected.

A very difficult problem requiring solution is the collection of seed of buffalo grass (*Buchloë dactyloides*). As the seed is borne very close to the ground and shatters readily, it was felt that the only practical means of collection would be by suction; several machines have been tried with moderate success. The latest improvements, however, have resulted in approximately 50 per cent efficiency in seed collection. This is governed by the amount of grass growth; 95 per cent of the seed has been obtained where the grass was not more than one inch high, but

this percentage seems to decrease in proportion to the height and the density of the grass. Enormous quantities of dirt, manure and vegetation are also collected and must be screened from the seed.

Practically no information is available regarding rate, time and methods of seeding the grasses, but nevertheless numerous sowings have been made during 1935 with gratifying success. It has been learned that the majority of the species harvested in quantity can be seeded with success under conditions where all cultivated grasses fail. Excellent stands of various native grasses have been obtained from seedings at 15 lb. per acre on badly eroded land. *Bouteloua gracilis*, for example, has germinated 36 hours after seeding, thus showing its ability to utilize light showers rapidly; the grass is extremely tenacious under long dry spells even in the seedling stage. This quality, which is also possessed by the introduced crested wheat grass, *Agropyrum cristatum*, is absolutely essential for successful establishment under semi-arid conditions. It seems that the rules for seeding cultivated grasses also apply to these native species, namely, the seed bed must be firm and well settled, the seed must be planted very near the surface, except on sandy land, and either early autumn or early spring sowings may be made if there is sufficient moisture. Autumn sowings are logical to avoid competition from the spring growth of weeds, but the danger of losing the stand from soil blowing is great, unless the ground is protected by permitting weed growth or crop remains to lie on the surface.

This work with the native grasses brings up numerous problems in connexion with seed germination. Extensive tests have been made during the last two years at several points in the field and in the Seed Laboratory, Bureau of Plant Industry, Washington, D.C. Seed of several species lose viability very rapidly after harvesting, other species show delayed germination, and still others refuse to germinate well under any known method of procedure.

## INDIGENOUS GRASS SPECIES.

As already mentioned, there are many species of native grasses that offer possibilities for use in reseeding, but of these several are outstanding and can be harvested from present stands. Athough buffalo grass, so definitely confined to the Great Plains, has been growing successfully for years at Washington, D.C., in Vermont and in California, the sowing of these native grasses on the basis of the area naturally occupied by the species in question is being recommended.

Undoubtedly the grass which is most promising for harvesting and use in reseeding is *Agropyron smithii* (western wheat grass of the Great Plains and bluestem of the intermountain region). The grass is found in practically every state west of the Mississippi river and sparsely in some states east of the Mississippi river. It is a fine native hay and grows in almost pure stands in localities from Montana to Arizona and New Mexico. Thousands of acres of fine stands grow in Nebraska and southern South Dakota, where the Soil Conservation Service harvested nearly half a million pounds of seed for projects in the western country. The grass grows like wheat and can be harvested with a combine, but naturally the land must be set aside from grazing or haymaking and reserved for the seed crops. The seed is fairly large, a desirable character for sowing on land with limited rainfall. *A. smithii* spreads by underground stems, but does not become as troublesome as *Agropyron repens*.

*Agropyron spicatum* (blue bunch wheat grass) is a very desirable grass native to a large area from Washington to northern California and east as far as Colorado. It was one of the very desirable grazing grasses of the Palouse wheat country of eastern Oregon and Washington before that land was ploughed for wheat. Several thousands of pounds of seed were collected from the excellent stands found in the semi-arid areas of the north-west. Where the land is sufficiently smooth this grass can also be harvested with a combine, header, or stripper. *Festuca idahoensis* (blue bunch fescue) is another desirable grass from the arid lands of the north-west which can be

harvested and handled in a similar way. *Andropogon scoparius* (little blue stem) and *A. fulcatus* (big blue stem) grow in practically every state of the Union, except the far west, but are of exceptional value for grazing in the Flint Hill region of Kansas. Their grazing value is recognized throughout the eastern Great Plains, but only recently has reseeding been considered and the first large scale seed harvest made. Seed can be harvested with ordinary farm machinery, but special attention must be given to threshing as its awned and hairy character make it rather difficult to handle. These bluestems are practically worthless for hay or grazing purposes in the eastern states.

*Buchloë dactyloides* (buffalo grass) is one of the most interesting and desirable grasses, as it formerly occupied much of the land from which the dust storms originated during the winter of 1934–35. This grass has always been highly regarded for grazing purposes, and it retains its palatability and nutritive value during the winter months after it has become brown and dry. Buffalo grass occurs throughout the low rainfall belt from Montana and North Dakota to Texas, although it is not abundant north of Nebraska. It is at its best in western Kansas and eastern Colorado. The grass is short, seldom growing more than three or four inches high and has both male and female plants. The male flowers grow above the grass, appearing as ordinary seed heads, while the female flowers occur near the ground where the seed is formed. Frequently quite extensive patches of one or other type alone may be found, perhaps originating from a single plant. The attempts to harvest the seed have already been mentioned. Buffalo grass has been re-established successfully by planting small pieces of sod spaced several feet apart, as it spreads very rapidly by means of prostrate runners provided sufficient moisture is present. The method is considered too expensive, however, for use on a large scale.

*Bouteloua gracilis* (blue grama) is a companion grass to buffalo with which it is frequently confused. It extends farther north than buffalo grass and is found in great abundance in North Dakota and Montana. It is much more promising for reseeding purposes, as the seed can be gathered with bluegrass (*Poa pratensis*) strippers. The seed yields are very low, but 80,000 lb. of seed have been collected for control projects by using these bluegrass strippers and a power stripper that will cover 35 acres per day. With the exception of western wheat grass, the greater part of the seed of all species has been collected with the power strippers.

*Sporobolus wrightii* (sacaton) is an excellent grass for reseeding in the dry regions of Arizona and New Mexico, where it makes very desirable hay; the seed can be harvested with ordinary farm machinery. The related species, *S. airoides*, is widely distributed and is also desirable for reseeding. A very large quantity of seed of these grasses is desired, and a considerable quantity has been harvested. *S. cryptandrus* and *S. asper* (dropseeds) are widespread in the west and may be valuable in the reseeding of ranges. A fair quantity of seed has been collected for trial plantings.

*Oryzopsis hymenoides* (mountain rice or Indian rice grass) is excellent for dry land and occurs throughout the Great Plains and west to the Pacific Coast. It presents commercial possibilities but occurs generally in scattered stands. The seed can be readily harvested with ordinary machinery, but germination presents difficulties.

*Sorghastrum nutans* (Indian grass) is a very good hay and grazing grass that occurs in mixtures with the bluestem, being a particularly valuable constituent of bluestem pastures and meadows of the eastern Great Plains from the Dakotas to Texas. In harvesting bluestem seed, some admixture of this Indian grass seed is almost certain to occur and is also desirable, as mixtures usually give a longer grazing period or greater yields of hay. The seed has long awns or beards and is hairy, thus being in the class of seeds that are naturally difficult to thresh, clean and sow with machinery.

*Stipa comata* (needle and thread) is an important grazing plant in the semi-arid areas throughout the west. *S. spartea* (porcupine grass) is found under more humid

conditions in the Dakotas and Nebraska and to the east. Both are good for grazing purposes, and seed has been collected with strippers, although the collecting season is short owing to the fact that the seed falls to the ground soon after ripening. Although there are more desirable grasses than these "needle grasses", they should not be neglected in the attempt to improve the vegetative cover of the western range.

Among other grasses which are of value for these purposes and of which seed is being collected are species of *Hilaria* and *Koeleria*, *Redfieldia* and *Calamovilfa* (sand dunes), *Ammophila* (coastal sand), *Puccinellia* and *Distichlis* (alkali lands).

The species so far mentioned have not yet been available in commerce. Three of the four grasses that are available on the market in a more or less limited quantity are not native to the American west. *Agropyron cristatum* is ideal for all the northern country, but has not been grown successfully south of northern Kansas. The seed is expensive and limited in quantity. *Bromus inermis* and the native *Agropyron pauciflorum* are also confined to the northern states. These three species are the best grasses commercially available for seeding in regions of low rainfall from North Dakota to Nebraska and West. At high elevation they can be seeded farther south. *Poa bulbosa* has been growing successfully for several years in Oregon, Washington and Northern California, and will undoubtedly be of value in the dry lands of South California, Arizona and New Mexico. This species is adapted to regions of winter rainfall; the grass emerges in the autumn, remains green throughout the winter, and matures a seed crop in May and June, when the tops die. The bulbs remain alive in the soil ready to send up shoots at the first autumn rains.

The dry land country of the west is primarily a grass country, and the encroachment of sage brush, the ever-increasing menace of floods, the gullying and surface erosion and the dust storms are all indications of the grave dangers ahead in the continued abuse of the grasslands of the United States. The Soil Conservation Service is making a desperate effort to meet the need for immediately covering a portion of the dry regions of the west with permanent grass, through the use of the native grasses just mentioned. Every effort will be made to interest farmers in the hope that they will undertake commercial seed production of these grasses.

### INTRODUCED SPECIES.

In 1934 expeditions to Turkestan, Turkey and China were organized and were successful in procuring species of grasses, legumes, shrubs and trees adapted to arid regions. Seed and planting material were distributed to western nurseries, an attempt being made to place the plants under conditions similar, as far as possible, to their native habitat. This was possible to a limited extent as far as latitude, rainfall and range of temperatures were concerned. It seems apparent, however, that many of the plants secured were more closely associated with soil than with climatic conditions. This was particularly true of the plants found growing on the sand dune country of Central Asia. For instance, *Aristida pinnata*, an excellent sand binding grass of the Karakum, was found only on sand, even though in many places heavier soil areas were abundant. This species occurred in the sand dunes from the Persian border as far north as the Chelkar Experiment Station, north of the Aral Sea, where winter temperatures may drop to 49° below zero F. Rainfall in much of the sandy desert may be as low as four inches and may reach seven or eight inches per annum. *A. pinnata* was sent to Tucson, Arizona, where it formed seed; it would appear to be a promising addition to the grasses which can be used for sand binding purposes. It is a bunch grass with remarkable ability to remain alive even when the roots are almost completely exposed in the extremely hot, dry summer weather. Undoubtedly, this is particularly due to the fact that the roots grow through small tubes of cemented sand grains which give protection from the intense heat.

Another plant that furnishes a very large portion of the grazing of the sand dune desert region of Central Asia is *Carex physoides*, a sedge which grows from 10 to 15

inches high and has underground root stocks. It is found only in the sand and has wide adaptation to climatic conditions. As the seed is apparently not viable it was necessary to introduce some of the underground root stocks for planting. Although these root stocks have been kept in a perfectly dry state for four months before being replanted, growth started immediately after they had been planted in sand in a greenhouse in Washington. Considerable difficulty has, however, been encountered in establishing this plant in the field.

There are many other plants that appear promising for sand dune control even in extremely dry regions. At Tucson, Arizona, several species of *Calligonum* and particularly *C. caputmedusae* are showing up very well. *Lycium ruthenicum, Agriophyllum latifolium, Astragalus confirmans* and *Agropyron intermedium* are making good growth. *Convolvulus divaricatus,* a bush type of the bind weed family, which is a very attractive ornamental plant, gives considerable cover in dry sand without becoming a pest. Among the interesting observations made in Turkestan was the presence of the pubescent form of *Agropyron sibiricum* at Chelkar on level sandy soil containing considerable humus, but with a hardpan at 1.5 to two feet below the surface. This type of sand breaks sharply at many points into a loose sand with practically no humus and without a hardpan. The plants of *A. sibiricum* on the loose sand were of a glabrous form sometimes known as *A. desertorum.* The pubescent form is found growing with *Artemisia maritima,* while the glabrous type is found with *A. arenaria.* Both these *Artemisia* species are palatable to livestock and are used for autumn and winter grazing of sheep and horses. In this region where the rainfall is approximately five inches per annum, and where the temperatures may vary from the minimum of 49° below zero F. to a maximum of 106° F., *Poa bulbosa* grows profusely and furnishes excellent winter and spring grazing. *Agropyron sibiricum, Stipa capillata* and *Stipa sareptena* furnish spring, summer and autumn grazing, while other plants that are of some grazing value are *Anabasis salsa* and *Atriplex caninum.* The Russians consider *Agropyron sibiricum* to be much more drought resistant than *A. cristatum.*

On the heavy alkali adobe soils, with the rainfall as low as four inches per annum, *Aeluropus litoralis* is a very promising grass for low areas heavily impregnated with alkali. It is very promising at Tucson, Arisona, particularly as a dry land lawn grass; it spreads by stolons and forms abundant seed.

*Andropogon ischaemum* is a very common grass on the adobe soils throughout Turkestan and Turkey, even under heavy conditions. It forms abundant seed and was one of the outstanding grasses sown in the spring of 1935 at Tucson, Arizona, and Stillwater, Oklahoma. It will, undoubtedly, be a very important addition to the plants that can be used for reseeding in the drier range country. Other species of this genus that are promising are *A. caricosus* and *A. intermedius.*

Of all the grass genera tested, the genus *Agropyron* has more promising representatives than any other. In addition to those already mentioned, *A. trichophorum,* which is particularly recommended by Russians as a grazing plant in Central Asia, is outstanding at Pullman, Washington. Several *Agropyron* species, including some not yet identified, are also promising at Pullman, Cheyenne, Wyoming, and Mandan, North Dakota.

*Pennisetum orientale* and *Erianthus ravennae,* both from the heavy adobe soils of Turkestan, are making the heaviest growth of all grasses introduced in the nursery at Tucson. Other grasses from the heavier soils of Turkestan and Turkey include *Oryzopsis coerulescens* and *O. miliacea, Agrostis transcaspia, Hyparrhenia hirta, Panicum coloratum,* and species of *Dactylis, Calamagrostis* and *Brachypodium.*

*Poa bulbosa,* which has been grown commercially for several years in the Pacific North-west, was found widely distributed throughout the dry deserts from the interior of Turkey even to the shores of the Mediterranean. The fact that *Poa bulbosa* grows in such conditions, where the winters are mild and the summers very dry, would

suggest that this species can be used to prevent soil washing and to furnish winter grazing as far south as the Mexican border in California, Arizona and New Mexico. The Soil Conservation Service has, therefore, purchased 50,000 lb. of seed of *Poa bulbosa* for planting in that region.

At Pullman, *Hordeum bulbosum* is the most promising grass importation as regards vigour, erosion control possibilities and drought resistance. *Elymus giganteus* and *E. arenarius*, also from Turkestan, are outstanding species of this genus. Legumes which are promising are *Vicia lutea* and *V. tenuifolia*, both from the mountains of Eastern Kazakstan, *Astragalus homosus* and *A. chinensis*, from the heavy soils of Turkestan, and *Medicago lupulina*, the "wild alfalfa" that is found growing naturally over wide expanses of Turkestan, particularly in Kirghisia.

At Cheyenne, the promising species include *Elymus sibiricus* and *E. dahuricus*, five species of *Poa*, *Bromus inermis* var. *sibiricus*, and species of *Festuca* and *Puccinellia*. The last named is particularly adapted to excessive amounts of alkali in the soil.

Promising species at Mandan include *Elymus pseudoagropyron*, *E. excelsus*, *E. dastystachys*, *Agropyron sibiricum*, *Bromus inermis*, *Stipa sibirica* and *Chloris virgata*.

## CONCLUSIONS.

On the whole it appears that erosion control methods can be found for practically any reasonable situation and that good progress is being made ; also that there is a steadily increasing appreciation of the value of vegetation in the varied programmes that are being set up for this purpose.

The most difficult problem in the entire field of soil and water conservation lies in the essential inertia and indifference of the individuals concerned. This indifference is largely based upon the antiquated ideas of land ownership that prevail at the present time—ownership rights that apparently permit a man completely to incapacitate, or even entirely destroy the soil on his farm in five, ten, or twenty years by the sheer crudeness of his methods of handling.

**In the preparation of this review extensive quotations have been made from the following publications :**


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2. BENNETT, H. H. Dynamic action of rains in relation to erosion in the humid region. *Trans. Amer. Geophys. Un.* 15th Ann. Meeting. 474–88. 1934.
3. ———— The tragic truth about erosion. 1934. See Schenectady, N.Y., The Forest Preserve Association of New York State Inc.
4. CARRIER, L. Improvement of permanent pastures. U.S. Dept. Agric. Soil Conserv. Serv. SCS–TP–3. Washington. 1936. pp. 5.
5. ———— Grass in soil erosion control. U.S. Dept. Agric. Soil Conserv. Serv. SCS–TP–4. Washington. 1936. pp. 15.
6. ENLOW, C. R. Regrassing semi-arid plains. [Paper presented to the] Amer. Ass. Adv. Sci., St. Louis. 1935. [Not yet published.]
7. ———— Promising introduced species. [Paper presented to the] Amer. Soc. Agron., Chicago. 1935. [Not yet published.]
8. GORRIE, R. M. The use and misuse of land. Oxford Forestry Memoirs. No. 19. 1935. pp. 80. pls.
9. LOWDERMILK, W. C. Soil erosion and its control in the United States. U.S. Dept. Agric. Soil Conserv. Serv. SCS–MP–3. Washington. 1935. pp. 12. [Paper presented to the] Third Internat. Cong. Soil Sci. 1935.
10. SCHENECTADY, N. Y. The Forest Preserve Association of New York State Inc. The tragic truth about erosion. [Reproduction of an article by] H. H. Bennett [with additional data.] Schenectady, N.Y. 1934. pp. 22.

## SEED PRODUCTION OF LUCERNE IN FRANCE.

An article has recently appeared in *Annales Agronomiques* by L. Alabouvette and G. Meneret on the importance of choice of lucerne varieties and the proper management to be adopted for increasing lucerne seed production in France.* The authors are directors of the Crop Improvement Stations at Versailles and Colmar.

This paper is divided into four parts.

(1) The origins of lucerne.
   - (*a*) Botanical and genetical significance of origin.
   - (*b*) Influence of the environment on the formation of types.
   - (*c*) Practical importance of source of lucerne seed.
   - (*d*) Means of determining origin.

(2) The comparative value of different types of French and foreign origin. Behaviour and forage production.
   - (*a*) Experiments at Colmar.
   - (*b*) Experiments at Versailles.
   - (*c*) The consequence of the importation of foreign seeds from 1932 to 1934.

(3) Management to increase lucerne seed production in France.
   - (*a*) Importance and markets of French seed.
   - (*b*) Localization and present state of production in France.
   - (*c*) Improvements necessary.

(4) Conclusions.

From the results of the experiments at Versailles and Colmar, the authors conclude that for the conditions of that part of France north of Paris the best seeds (as regards disease resistance and productivity) come from Poitou-Vendée and the Centre. Where French seed is not available, first preference must be given to Hungarian, and second to Italian. For other parts of France such as the Midi the classification may differ, and Provence may take first place.

During the years 1932 to 1934 very considerable quantities of seed were imported into France. Unfortunately, only 4 per cent of these imports represented varieties with a cultural value comparable with French lucernes (Hungary, Rumania, Italy). The remainder came from Argentina (40 per cent), United States (29 per cent) and South Africa (15 per cent), representing types proved to be most susceptible to mildew attack. The effect of this contamination of future seed crops from French lucerne leys will obviously be considerable.

### Export of Seed.

Lucerne in France occupies an area of 1,130,000 hectares ; assuming three to four years as the average duration of a ley and 25 kg. per ha. as the seed rate, the annual consumption of seed can be said to be seventy to eighty thousand quintals. In spite of the annual fluctuations due to climatic conditions, the average production generally exceeds requirements. The average for the years 1927 to 1930 was 98,000 quintals, leaving 18,000 quintals available for export ; in 1932 and 1933, however, the amount produced was markedly below requirements.

The assured markets for French seed include countries such as Switzerland, Germany, Belgium, Denmark and Sweden, which can cultivate lucerne but cannot produce seed owing to climatic reasons. Besides these regular importers, there are other countries (Balkans, South Africa, Argentina and North America) which import more or less frequently. The authors state that France is in danger of losing her position as an exporter of lucerne seed, not only because other countries produce cheaper seed, but also because France has made no attempt to organize and perfect her production, while other European countries, Hungary in particular, have worked

* Alabouvette, L., and Meneret, G. Importance du choix des provenances de luzerne. Orientation à donner à la production des semences de luzerne en France. [Importance of choice of lucerne sources. Management to increase lucerne seed production in France.] *Ann. Agron.* 5. 407–45. 1935.

successfully at the improvement of lucerne. Thus if in German, Swiss and Swedish trials, Provence lucerne has maintained an honourable position and is generally classed with Italian lucerne, it is frequently inferior to Hungarian lucerne and to the German and American hybrid lucernes. A serious effort must therefore be made to adapt production to post-War conditions and to increase the export value of French lucerne seed.

## LOCALIZATION AND PRESENT STATE OF PRODUCTION.

Three regions are fairly regular producers of seeds :

(1) Provence and the Mediterranean Midi (Basses-Alpes, Ardèche, Bouches-du-Rhône, Drôme, Vaucluse, Gard, Aude).
(2) The Basin of Aquitaine (Tarn, Haute-Garonne, Gers, Tarn-et-Garonne, Aveyron, Lot, Lot-et-Garonne, Dordogne, Charente, Charente-Inferieure).
(3) Poitou, Vendée and the Centre (Vendée, Deux-Sèvres, Vienne, Indre, Char, Indre-et-Loire).

These twenty-three *départements*, comprising 40 per cent of the total area under lucerne, supplied 92 per cent of the total seed produced in 1930 (Provence 44·5 per cent, Aquitaine 31 per cent, and the Centre 16 per cent). The figures for the different regions naturally vary from year to year according to the climatic conditions prevailing.

Even in Provence, the production of seed is rarely the sole preoccupation of the lucerne cultivators. Forage is the primary requirement ; seed is taken only when the forage production is assured and when climatic conditions during flowering would suggest a good seed yield. Production is therefore very irregular. Seed houses arrange contracts with farmers for the production of seed of cereals, beet and vegetables ; the seedsmen choose the varieties, generally of a selected strain, and reserve the ownership of the harvest. This is not so with lucerne. Commerce restricts itself to the collection of any seed that may be produced, sometimes in the Midi, sometimes in the Centre, and leaves all the initiative and risk to the cultivator. This seed is subsequently sold as *Provence*, *Poitou* and *Pays*, according to external appearance and the type of impurities.

## IMPROVEMENTS.

The first and most important step to be taken is to prohibit the production of seed from crops grown from seeds of foreign origin which are known to show susceptibility to disease and lack of adaptation. Probably in all parts a few farmers can be found who have conserved and multiplied local stocks without introducing foreign seeds. These farmers must be sought and their seeds multiplied ; the authors consider this to be the most rapid method of improving the cultural value of French commercial lucernes.

The second step suggested is the recognition of "brands" of lucerne seed characteristic of the different seed production regions. If these are kept distinct, future purchasers of, for example, Provence lucerne would know that their seed had actually been produced in Provence and that it would be well adapted to similar conditions elsewhere.

The greatest obstacles to the improvement of lucerne which discourage farmers from producing seed regularly are the uncertainty of yield and the great fluctuations in price. Farmers have not, however, taken proper care of their seed leys, many of which are too old and have become infested with *Cuscuta* and other weeds. Even allowing for climatic variations, it is possible by proper selection of locality and by proper management, including perhaps irrigation in dry years, to obtain remunerative average yields of seeds of a quality acceptable in commerce.

Fluctuations in price may be avoided to a certain extent by storing excess seed from one year to another, since lucerne seed stored for several years maintains its germinability.

## ECOLOGY OF THURINGIAN MEADOWS.

[Reviewer: G. M. Roseveare.]

E. KLAPP and A. Staehlin have just published a study of grassland ecology embodying the results of several years' repeated and intensive examination of a large number of widely different meadow types in Thuringia,* interim reports on which have appeared from time to time in different periodicals (see *Herb. Abstr.* 2, 26–7, 1932; 3, 171 and 231, 1933; 4, 91 and 254, 1934). Their findings are summarized as follows.

The foregoing work is not concerned either with the mere description or solely with the agricultural evaluation of grassland stands, but primarily with the relationship of their composition and their transformation to locality and the effects of utilization, wherein it goes back to fundamental problems such as have already been raised by Stebler and Schröter.

Herein the manner of consideration can be neither purely phytogeographical nor purely economic and statistical, botanical and agricultural science having developed upon too widely divergent lines for this to be possible. The units of present-day sociology are still much too comprehensive, the degrees of its scales too widely spaced for it to be employed in making even very broad distinctions between stands. The greatest danger, however, appears to lie in the striving after a system of abstract associations into which the majority of the meadow plant stands can be introduced only by force.

The agronomical study of grassland, on the other hand, must naturally lay special emphasis upon the relation of important species to locality and form of utilization, and upon their value and bulk. In so doing, a sense of the biology and the indicator value of the different plant associations is all too often lost, and therewith the most valuable aspect of the problem. That manner of consideration which unites these two points of view, such as is to be found in the work of Stebler and Schröter and again in that of C. A. Weber, appears to be desirable and the only fruitful one.

The investigations covered 416 meadows, which were the object of repeated examination throughout 1930, 1931, and 1932, and afforded approximately 2,600 lists of species. Detailed information is given concerning the basis of this repeated examination and of the individual data on stand and locality. In the choice of the areas studied, it was not the search for well-developed "association individuals" that was the criterion, but the attempt to obtain an average picture of all the agriculturally and economically important forms of meadow which are distinguishable in Central Germany (in the more limited sense); for this reason the localities of the meadows studied embrace great extremes. It was desired to ascertain from the results of the examination what relationships exist between plant stand and locality, and whether natural grouping without a pre-conceived scheme is possible.

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* Klapp, E., and Staehlin, A. Standorte, Pflanzengesellschaften und Leistung des Grünlandes, am Beispiel thüringischer Wiesen bearbeitet. [Localities, plant associations, and yield of grassland, as exemplified in Thuringian meadows.] 23 × 17. pp. 122. Stuttgart: Verlag Eugen Ulmer. 1936. RM. 6.90. [Inst. f. Acker- u. Pflanzenbau d. Landw. Hochschule, Hohenheim, Stuttgart (E.K.), and Forschungsstelle f. Grünland u. Futterbau, Thür. Landesuniversität, Jena (A.S.).]

The first most important question concerned the extent of the occurrence of species which are ecologically and sociologically "true," which can serve as characteristic and differential species for a reliable, natural grouping of plant stands. In order to answer this question, a large part of the results was grouped according to directly opposite environmental conditions, wherein it is seen that extreme localities (very poor, sour, very dry or wet, very salt) are distinguished by a whole series of ecologically true species, but that the more favourable the locality for the growth of herbage, the more such species are lacking.

Similar findings are obtained from a more detailed subdivision of the material from thirteen groups of localities classified according to degree of moisture and nutrient content: most of the species are to be found throughout many classes, among them species after which associations are named, but which, without any doubt, are little characteristic in themselves. Only a series of species of extreme localities appears to be strictly specialized in an ecological sense (heath plants of sour and alkaline soils, marsh and salt plants). The species of valuable grassland presenting no ecological extremes generally appear to be very adaptable.

If, further, mass occurrence and association of species under definite local conditions are considered, it is found that many species can be dominant without, however, forming associations that are ecologically or sociologically characteristic. Such accumulations of species are therefore of practically no value as indicators; their usual definition in recent literature as "types" or "associations" should be rejected. The mass occurrence of a species is characteristic and formative of type only if it is possible under very limited local conditions. Thus a narrow ecological specialization of mass occurrence in the place of occurrence is found principally in the case of ecologically and sociologically true species. Ubiquists like *Festuca rubra* or *Poa pratensis* form no characteristic type; they can be dominant in several quite different associations. Only approximately 20 per cent of the plant stands examined are sufficiently clearly distinguished by their plant community as to correspond somewhat to the conception of association. These are, in agreement with what has already been said, meadows of extreme localities, for example, Nardeta or Brometa. As one proceeds in the direction of the "fat meadowlands" of fresh to moist localities, identification by means of characteristic and differential species becomes more and more difficult, and finally impossible. Here bulk and vigour in a series of species that are in themselves by no means true or characteristic, together with local conditions and manner of utilization, are of preponderant importance as characters of the stand.

The Nardeta on the one hand, the Arrhenathereta on the other, for example, embody categories of quite different value. The former (although not in every case) are clearly distinguished by a whole series of ecologically and sociologically true species; in the latter such species are the more lacking, the greater the bulk growth of the stand. This finding is entirely in agreement with the very different degree of uniformity and reliability exhibited in the description of these two types of meadow in plant-geographical literature. The employment of the same principles for the classification of all kinds of plant stand meets again with considerable difficulty in that, from extreme localities to those favourable for meadow growth, there are found a considerable number of invasions and formations of sub-types.

While, however, the general study of vegetation can be limited to the search for well-developed individual associations or their stages of development and fragments, we are concerned with an arrangement, as far as possible complete, of all the existing meadow stands, including those which are of uncertain sociological determination. For this purpose it is necessary to supplement floristic characters by statistical, ecological, and in part also by technical and agronomical characters. For the same reason it is advisable to forego the term "association," which can be used with accuracy only in rare cases, and to go back (for the purposes of agricultural science,

be it understood) to the wider terms "type" and "sub-type" as employed by Stebler and Schröter.

A comparison with the *Meadow Types of Switzerland* [Stebler and Schröter, 1892] actually shows a very considerable degree of conformity between our meadows and comparable localities in the north-east of Switzerland. The principal differences lie in the rareness of the marked *Molinia* type in Thuringia, which may be explained by ecological and agronomic influences, and in the great importance of the *Alopecurus* stands in Thuringia. That the latter were given no prominence by Stebler and Schröter, although they are often fully developed in the land at the foot of the Alps, is presumably due to a recognition of their unsatisfactory sociological characterization.

Various classifications are possible, in accordance with the characters to which most importance is attached. When, however, all points of view, sociological, ecological, and those of grassland importance are taken into consideration, the following grouping of the meadows of Thuringia may perhaps be the most satisfactory:

(1) *Nardus stricta* meadows as the type of heathland meadow on poor, sour soils in cool localities.
(2) *Bromus erectus* meadows as the type of heathland meadow on dry, neutral to alkaline soils in warm localities.
(3) *Avena flavescens* meadows as the fresh and fat meadow type of higher altitudes (partly as Umbelliferae sub-type).
(4) The same, with a preponderance of moisture-loving species (*Alopecurus pratensis* sub-type).
(5) *Avena elatior* meadows as the fresh and fat meadow type of lower altitudes (partly as Umbelliferae sub-type).
(6) The same with a preponderance of moisture-loving species (*Alopecurus pratensis* sub-type).
(7) Sedge meadows (with traces of *Molinia coerulea* meadows) as the type for moist localities with little water movement.
(8) *Carex gracilis* meadows as the type for wet localities.
(9) Salt meadows as the type for low-lying land rich in sodium chloride.

Two to four important sub-types may be easily separated from each of these sufficiently clearly defined collective types. Special emphasis of the *Alopecurus* sub-types included in types 4 and 6 appeared necessary, because they play an important part in regard to frequency and productivity. Of still more importance, but less clearly definable, are the Umbelliferae sub-types of types 3 and 5.

For the rest, one may always be in doubt as to the inclusion in a definite type of the one or the other sub-type or mixed type. There are no sharply defined limits. From the definitely *Nardus* type almost imperceptible transitions lead with an increasing appearance of *Agrostis vulgaris*, etc., to the *Avena flavescens* type, and from this to the *Avena elatior* type and so forth. Moreover, the allotment of sub-types to types follows not from the floristic and sociological point of view alone, but also from that of grassland management.

The local characteristics of the nine collective types—climate, soil properties, cultural influences—naturally exhibit a certain amount of overlapping; yet if one eliminates all transitions, there is given a fairly close ecological specialization for the pure types, which to a certain extent then correspond to the concept of the association. Herein fresh light is thrown upon the great value of plant stands as indicators.

The same holds good in the case of productivity. It overlaps in the collective types to a considerable extent; characteristic features of the type permit, however, of a very reliable forecast of potential yield, and it is only a matter of experience to be able to make a correct estimate even of the effect of sub-type formation and of the invasion of other types upon yield.

An ecological and economic grouping of the types may be most briefly expressed as follows :

| Meadow type. | General climatic and soil conditions | Degree of moisture | Manurial condition, productivity |
|---|---|---|---|
| Salt meadows .. | Warm—dry—rich in nutrients—alkaline | wet | poor to moderate |
| *Bromus erectus* .. | | dry | |
| *Avena elatior* (dry) .. | transitions | fresh | good |
| *Avena elatior* (moist) | | moist | |
| *Carex gracilis* .. | | wet | moderate |
| Sedge .. .. | | | |
| *Avena flavescens* (dry) | cool—moist, in part poor in nutrients, very sour | fresh | good |
| *Avena flavescens* (moist) | | moist | |
| *Nardus stricta* .. | | dry .. | poor |

The number of species essentially concerned in the building-up of yield (with more than 0·7 percentage weight in the total average) scarcely amounts to one-tenth of the species actually present ; in addition to 20 grasses they are mainly Compositae, Leguminosae and Umbelliferae. The participation of the agriculturally important or even the valuable species varies very much according to the meadow type concerned. The proportion of forage plants, for example, lies between 40 and 80 per cent, that of poisonous plants between 2 and 33 per cent, in accordance with the type of meadow. When one attempts to evaluate the quantity and quality of yield by marking, a range of from 21 to 104 marks is obtained.. The evaluation of hay according to botanical composition already demanded by Schindler [1886] is thus forced upon one.

Naturally the meadow types are not entirely stable. Possibilities of transformation exist in the many-sidedness of the governing influences—annual variations, land improvement (water regulation in particular), cultural measures, manuring, form of utilization. Some examples are given of transformations which may frequently be observed.

A far greater part is played by quantitative dislocations within one and the same meadow type ; these dislocations, moreover, constitute one of the reasons why the mere qualitative evaluation of a meadow from its component species must lead to very erroneous conclusions.

To endeavour to present these dislocations in their many aspects would considerably exceed the limits of this work. It is sufficient for agricultural purposes (partly also for biological purposes) to trace the variations in the ratio of good grasses : legumes : species other than grasses and legumes. It amounts on an average to approximately 48 : 11 : 41 per cent of the yield. The proportion of grass is generally in reverse ratio to that of everything else ; that is to say, the ideal meadow rich in grass and legumes but poor in weeds is hardly ever found (with the occasional exception of new sowings or frequently grazed meadows).

The effect of the different years from 1928 to 1932 was seen principally in a reduction of the proportion of grasses and an increase of all the miscellaneous herbs (a consequence of the drought and cold winters of 1928–9) ; from 1933 onwards a reverse process has set in. Hand in hand with these alterations a complete transformation of the aspect of the meadows often took place, the proportion of flowers increasing perceptibly up to 1932.

The well-known seasonal variation from the first to the second cut was expressed also in the diminution of the proportion of grasses and in the increase of that of other species, wherein, in accordance with the conditions under which they competed, now the legumes and now the miscellaneous herbs became prominent. A special part was played herein by the Umbelliferae, according to the time at which they shoot and flower respectively (*Anthriscus silvestris—Heracleum Sphondylium*).

Of the biotic influences, that of manurial treatment is the most effective and thus the most well known. With a certain degree of regularity artificial fertilizers with much nitrogen are wont to encourage the proportion of grasses and of some nitrophilous herbs, fertilizers lacking in nitrogen the proportion of legumes. Of the organic manures those with an abundance of nitrogen easily lead to overmuch dominance by Umbelliferae. In individual cases, the manysided conditions of competition result in many exceptions to the rule. On very poor land, for example, manuring of *any* kind can result in the encouragement of Leguminosae.

After manuring, the next most decisive influence upon the ratio of grass : clover : weeds is exercised by the form of utilization. Frequent cutting lessens the competition of tall top grasses and herbs, and thereby directly encourages the low-growing grass and legume species. With continuous grazing, there are added the direct effects of trampling and cropping, so that as a rule particularly striking dislocations ensue. Plants important as sociologically characteristic are just as much suppressed thereby as by the application of heavily acting manures, usually with great rapidity.

Among the foundations of meadow yield the general water supply takes a prominent place. In this connexion the water table, the physical nature of the soil, and the climate are able within certain limits to replace one another. Favourable water supply somewhat neutralizes other local influences. Yield is directly reduced, however, under large quantities of rain (increasing altitude, diminishing warmth, and duration of growth period). Hilly localities appear to be especially productive of optimal yields ; less so the lowest, warmest, and driest situations and the lower hill localities ; it is quite rare for more than average yields to be obtained in hill country over 650 m. in altitude.

Soil type in itself plays no part in the matter of yield, given comparable water supply ; nevertheless light soils have a tendency to increase, and binding soils to lessen variation in yield. As humus and nitrogen content rises, the yield decreases. Here a case of indirect effect is seen, in so far as soils rich in humus and nitrogen are found almost exclusively in high hill country or in wet, sometimes saline, depressions. In the hill localities it is principally the very sour reaction of the humus layer which, in addition to climatic conditions, is the cause of reduced yield.

The influence of soil reaction makes itself clearly evident in the extremes, especially in the case of very sour soils. Here also good water supply and binding soils tend to lessen variation in yield; drought and clay-deficient soils, particularly those rich in humus, to increase it. The calcium carbonate content, when a minimum has been exceeded, exhibits only an indistinct influence upon yield.

With increasing root-soluble potassium and phosphorus content, yield slowly increases : here also dry localities show greater variation in yield than moist ones.

After the water relations of a locality, manurial treatment presents the most effective complex of factors. The yields are, under comparable manurial treatment, relatively greater in hill country than in the better cultivated meadows of the lowlands.

The closest sward is not found in the most productive meadows, the tall plant stand of which permits of little undergrowth ; but the presence of many gaps certainly reduces productivity. An increasing proportion of moss tends finally to reduce yield, or, to put it more clearly, optimal moss localities are poor meadow localities.

Only indistinct relations exist between the number of species in a stand and its productivity. In accordance with the grass : clover : weed ratio, also, yield varies

within narrow limits only. If finally one examines the question of the species which play the principal part in the different yield classes, they are naturally found to be closely related to the meadow types. The lowest yields are correlated to the dominance of *Nardus stricta* and its principal companion species, the highest yields to the leading species of the fresh to moist *Avena elatior* meadows.

The work is illustrated by photographs, there is a large number of tables showing the constancy, frequency, etc., of various species in different meadow types, and a bibliography of 156 references is appended.

## THE SWEDISH SEED ASSOCIATION.

[Reviewer: R. Peter Jones.]

THE annual report on the work of the Swedish Seed Association, Svalöf, during the year 1934, by H. Nilsson-Ehle, has appeared in *Sveriges Utsädesförenings Tidskrift* (45, 209–64, 1935). A report, by A. Müntzing, of the work of the cytological department of the Association during the period October 1, 1931, to September 30, 1935, has appeared in the same volume (pp. 305–20).

The work of the Association in 1934 was approximately equal in scope to that of previous years. Only at certain branches were the investigations extended to some extent with the help of various grants. The work of plant breeding has, as formerly, resulted in new varieties of cereals, meadow plants, etc., intended for different parts of Sweden. These new varieties indicate progress in yield, quality, and other characters of practical importance. Some have been bred at Svalöf, others at the branches. Two new varieties of timothy with high yield and luxuriant aftermath were grown at Svalöf. The breeding of pasture plants has now resulted in several valuable new varieties of *Poa pratensis*, *Festuca rubra*, *Trifolium repens*, etc.

Great attention is at present paid to quality breeding, both in cereals and in meadow plants. For this reason the studies at the chemical laboratories have been extended considerably. By collaboration with other institutions, it has been possible to carry out these quality investigations more satisfactorily. Of great importance for plant breeding has been the collaboration with the State Plant Protection Institute.

The Association has also collaborated with the Institute for Genetical Research of the University of Lund. Certain remarkable results have been obtained from trials to increase the frequency of mutation by means of external agencies.

The main object of the Association in the immediate future is to bring about the division into separate departments of the very large and (particularly for the central and northern parts of Sweden) especially important meadow plant department. During the course of the years the department has grown more and more in extent and economic importance, and is at present too large to form only one department. The immediate aim is to have a separate breeding department for pasture plants. At the present time, when the sowing of permanent pasture leys is being extended every year, it is very important that the best seed for the purpose should be available as soon as possible.

### BREEDING OF MEADOW PLANTS.

The protracted drought during the spring and early summer had a very detrimental effect on the meadow plant trials conducted by the Association during 1934, particularly in the first year leys of white clover and pasture grasses. As the year was particularly favourable for both the clover eelworm and clover stem rot, the clover plots in the first and second year leys showed a severe attack by both parasites, as a result of which it was possible to draw a number of conclusions concerning the resistance of the different strains.

Varying resistance to the clover eelworm was clearly manifested in the trials laid down on soil infested with the pest; the new Svalöf red clover bred from the Spannarps strain has always proved most resistant.

In the work with meadow plants, the plots of cuttings grown in 1932 of more or less self-fertile red clover have during 1934 exhibited still greater differences in regard to resistance to diseases, and have given rise to continued selection and multiplication. In common with 1932 and 1933, the year 1934 was an exceptionally good seed year for lucerne. Germination tests with lucerne seed harvested at different times during

the autumn showed that lucerne seed harvested early in the "green ripeness stage" can be made to germinate normally by after ripening—a circumstance of the greatest importance for seed production and breeding.

A new inbred generation of white clover has been produced and planted out during the year. The new variety of *Poa pratensis* 244–57/1929 is particularly promising at Svalöf and the branch stations. Autumn sowings of the *Poa* species have given very good results.

One hundred new varieties of hay and pasture plants have been spatially isolated during the year for multiplication.

## CYTOLOGICAL DEPARTMENT.

### Phleum pratense.

*Plan.* Crosses between *Phleum pratense* and wild timothy (*Phleum nodosum*), and also between *nodosum* and different *alpinum* types for the production of new types of timothy.

*Results.* By crossing *nodosum* with 14 chromosomes and *alpinum* with 28, Gregor and Sansome have succeeded in producing a synthetic timothy type with 42 chromosomes. This agrees essentially with ordinary timothy, in which the somatic number is also 42. Gregor and Sansome could not produce hybrids between *pratense* and *nodosum*, and consider, therefore, that the 14-chromosome wild timothy is separated from the 42-chromosome cultivated timothy by an absolute sterility barrier.

During a cytological examination of the timothy material of the meadow plant department, with which the chromosome department began its work, several timothy types were found to have either 14 or 42 chromosomes as expected, but in addition some plants with 35 or 36 chromosomes were discovered. From these plants, which must be descendants of spontaneous hybrids between *nodosum* and *pratense*, progenies were bred after isolation. As one would expect, the plants showed here very marked variation both in chromosome number and external characters (cf. Müntzing *Herb. Abstr.* 5, 80, 1935). Certain plants were particularly vigorous, and appeared to constitute a valuable combination of *pratense* and *nodosum* characters. Several of these plants, which were also examined cytologically, were selected for further work and were intercrossed in isolation cages. The next generation has been laid out in a comparative trial with three commercial varieties as checks. Weighing and fertility figures from this trial indicate that there is a good prospect of breeding valuable new varieties of timothy from this material. Several families were seen to have a higher yield and better aftermath than the three check varieties.

Recently it has been possible to produce artificial $F_1$ hybrids between *nodosum* and *pratense*. A male-sterile *nodosum* type was used as seed parent in this case. One would expect that the chromosome number in the $F_1$ hybrids would be 28 (7 + 21), but not a single $F_1$ plant proved to have this number. The majority of the plants had 35 chromosomes, a few plants 49 chromosomes. This must be due to the production of egg cells with 14 and 28 chromosomes in the mother plant used. These $F_1$ plants are still young, but give the impression of being particularly vigorous. As in addition fertility is good, the progeny is being eagerly awaited.

Hybrids between diploid and tetraploid *alpinum* have also been investigated, and seed has been obtained from a series of other species crosses.

*Future work.* Study of the progenies from the 35- and 49-chromosomed hybrids on the largest scale possible. In the progeny from 49-chromosome plants one should be able to obtain some with still higher numbers, e.g. 56. New selection and intercrossing of plants which originate from the spontaneous *nodosum* × *pratense* hybrids. New crosses, particularly *nodosum* × *alpinum*, for repetition of Gregor and Sansome's results, and also (*nodosum* × *alpinum*) × *pratense* for production of triple hybrids and new types in their progeny.

### Dactylis glomerata.

*Plan.* Cultivated cocksfoot, *Dactylis glomerata*, has 28 chromosomes, while a wild related species, *Dactylis Aschersoniana*, has 14. As cultivated timothy (2n=42) originated through crossing between 14- and 28-chromosome varieties of timothy, it should be possible to obtain hexaploid cocksfoot types with 42 chromosomes in the progeny from hybrids between *Dactylis glomerata* and *D. Aschersoniana*.

*Results.* As it was found to be very difficult to cross *glomerata* and *Aschersoniana* directly with one another, a series of spontaneous hybrids was procured from various localities near Svalöf where the two species grew together. These hybrids, which have 2n=21, are completely male-sterile with partial female-fertility. It has been possible to obtain progeny after pollination with both parent species. Back-crossing between the triploid hybrids and *glomerata* was particularly interesting. Several plants from this combination have $\pm$ 35 chromosomes, that is, a larger number than either of the parent species. These pentaploids are in general very well developed plants, more vigorous than ordinary cocksfoot. They have also in contrast to their triploid mother plants surprisingly good fertility. Progeny can be obtained without difficulty after self-fertilization, but owing to the aberrant chromosome numbers which the majority of such plants must possess, this progeny is on the average poorer than the mother plant. Through selection of plants with high chromosome numbers it should, however, be possible in succeeding generations to produce new, vital, and constant types of cocksfoot with 42 chromosomes. Already plants with 38, 39, and even 41 chromosomes have been obtained.

By the study of chromosome behaviour in *Dactylis glomerata* it has been found that this species forms with considerable frequency so-called aberrants with chromosome numbers which differ slightly. These have poorer vitality and fertility than plants with the normal chromosome number 28. The cause of this aberrant-formation is that *glomerata* is autotetraploid and therefore forms quadrivalents in the reduction division (cf. Müntzing, *Herb. Abstr.* 3, 188, 1933).

*Future work.* Production and investigation of pentaploid progenies on as large a scale as possible to obtain a series of 42-chromosome types. The production of new pentaploids through new crosses of triploid $\times$ *glomerata*. Selection of high-yielding triploids, pentaploids, and pentaploid descendants. Comparative experiments with the most complete cytological control possible.

### The Poa Species.

*Plan.* Chromosomal investigation of the economically important species *Poa pratensis* and also of some closely related species (*Poa alpina*, *Poa palustris*, and *Poa trivialis*) to obtain starting points for further work in accordance with the general programme of the department.

*Results.* Through combined genetical and cytological investigations it has been shown that all the *Poa pratensis* types examined and also certain *P. alpina* varieties have asexual, apomictic reproduction (see Müntzing, *Herb, Abstr.* 3, 33, 1933). As certain *P. alpina* types and a *P. pratensis* type which originated spontaneously proved on the contrary to be normally sexual, it was possible to study the inheritance of the apomictic method of reproduction by means of crosses between sexual and apomictic biotypes. In connexion with these researches various cases of doubling of chromosome number have been observed and the effect thereof investigated.

*Future work. Poa pratensis* is one of the most important pasture grasses in Sweden, and thus constitutes interesting and valuable material from the breeding point of view. This also applies to a lesser extent to the other *Poa* species mentioned. In the circumstances, a knowledge of the method of reproduction is of fundamental importance for the breeding and seed production of these species. A closer investigation of chromosome behaviour and type of reproduction thus forms part of the department's programme.

## SEED PRODUCTION IN NORRLAND.*

[Reviewer : R. Peter Jones.]

THE third volume in a series of handbooks for farmers, published by Nordisk Rotogravyr, Stockholm, has been published under the title of *Norrländsk Vallfröodling*. The senior author, Dr. F. Nilsson, is director of the Västernorrland branch of the Swedish Seed Association and secretary of the Västernorrland Seed Growers' Union ; Mr. G. Ericsson is director of Offer, the State Experiment Farm.

The most important crop in Norrland is the ley with its mixed stand of grasses and legumes, above all timothy, red clover, and alsike clover. The quality of the seed sown is of the greatest importance, being in many cases the factor which determines the yield of the leys and the economic results. It is, therefore, obvious that the production of seed of meadow plants is a very important branch of agriculture, and one to which adequate attention must be paid.

The application of rational seed production of meadow plants in Norrland has not yet been the subject of fundamental investigation, so that exact results are available only to a very limited extent. Practical experience has been gained and more or less casual experiments have been conducted in many places, but no summarized account of them is available. The authors have, therefore, considered it advisable to publish this book, in which the data obtained have been brought together.

Only 30 per cent of the annual consumption of seed of meadow plants is produced in Norrland. The deficiency is met by purchase from Central and South Sweden. Under the severe climatic conditions prevailing in Norrland this seed has not nearly so high a cultivation value as that of the so-called "local strains." The object of the authors is to disseminate a more general knowledge of the valuable properties of the "indigenous" cultivation material and to bring about an increased seed production based on more rational methods.

The book is divided into four parts.

Part I deals with Norrland ley cultivation and seed production of meadow plants. It comprises the following sections : Historical review ; the present position and extent of ley cultivation ; the most important meadow plants in Norrland agriculture ; various strains and their importance ; the need of seed production of meadow plants in Norrland ; general prerequisites for seed production of meadow plants in Norrland ; measures for furthering Swedish seed production.

Part II treats of applied seed production of meadow plants in Norrland. Instructions are given regarding sowing, manuring, management, harvesting, and threshing. The importance of strain is emphasized. The species dealt with are *Trifolium pratense, T. hybridum, T. repens, Phleum pratense, Festuca pratensis, F. rubra, Poa pratensis, Alopecurus pratensis, Agrostis* sp., and *Poa palustris*.

Part III deals with cleaning of seed. An account is given of the seed cleaning movement and its importance for the development of seed production. The processes of hulling, cleaning, and grading of seed of meadow plants are dealt with, and descriptions are given of many of the machines in use.

In Part IV an account is given of the official institutions for the promotion of Norrland ley cultivation and seed production of meadow plants.

The authors summarize their views on seed production of meadow plants in Norrland in a statement of 20 points as follows :

(1) Norrland ley cultivation comprises 68·8 per cent of the arable area and the hay crop represents a value of approximately 60 million kronor.

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*Nilsson, Fredrik, and Ericsson, Gust. Norrländsk vallfröodling. [Seed production of meadow plants in Norrland.] Pp. 138 + 32 illustrations in the text. Nordisk Rotogravyr, Stockholm, 1935. Kronor 2:75; cloth, kr. 3:75.

(2) Only 30 per cent of the requirement of seed of meadow plants is produced in Norrland. The seed deficit is valued at three million kronor a year and has to be met by purchasing seed from the south of Sweden, which is of low cultivation value for Norrland.

(3) The conditions for seed production of grasses and alsike clover for the farmer's own use are quite good in large areas in Norrland.

(4) Production of seed of timothy and also of alsike and red clover for the farmer's own use must become more general.

(5) Home-grown seed is reliable and saves the expense of buying seed for sowing.

(6) In the better agricultural districts of south and central Sweden the production of seed of meadow plants should be practised to meet the need which always exists in certain of the more northerly and inland regions of Norrland.

(7) Valuable strains of red and alsike clover and also of timothy are available ; these must be utilized in seed production as well as in ley cultivation.

(8) It is desirable that seed production should be practised more rationally in various respects.

(9) Seed production is a special cultivation and requires interest and knowledge in order to win good results.

(10) An intensive struggle to check weeds must always be carried on to obtain seed of good quality.

(11) It is of importance to observe the time of cutting, and the work of harvesting should be performed with care.

(12) Threshing, hulling, and cleaning should not be delayed but should be done immediately after the crop has been carried. Seed cleaning depots must co-operate to that end, otherwise the supply of seed of meadow plants cannot be ascertained in time for arrangements to be made for the distribution of the surplus.

(13) It is desirable that each seed grower should retain a reserve of seed for sowing, particularly of clover seed, until the following year, as the possibility of the harvest being poor then must be borne in mind.

(14) Threshing and hulling injuries reduce the cultivation value of seed of meadow plants and must be avoided as far as possible.

(15) Immediately after cleaning, the seed should be tested at the seed testing institute to determine its cultivation value in various respects.

(16) The future of seed production in Norrland depends to a great extent on a sufficient number of well-equipped seed cleaning depots being available. A general union of seed growers' associations with thoroughly reliable seed cleaning depots is desirable.

(17) A well organized and business-like distribution is necessary to obtain a fixed quotation of prices of seed for sale and to avoid competition with seed of southern origin. It is important that the sale of Norrland seed of meadow plants should be controlled as soon as possible, certificates of sealing being issued to give proof of genuineness of strain and cultivation value.

(18) The seed law requires that an analysis certificate should be furnished when seed is sold ; the buyer should always insist on this and should take an interest in the particulars given.

(19) It is desirable that farmers should meet for interchange of experiences. Branches of provincial agricultural societies have a great task to perform in this connexion, and should arrange for important matters to be discussed at their conferences. It should be possible to obtain the services of lecturers on application to the agricultural society concerned.

(20) Unity is strength. With concerted action Norrland seed production of meadow plants will go far.

## MANURING OF SWEDISH MEADOWLAND.

[Reviewer : R. Peter Jones.]

THE importance of the proper use of the various artificial fertilizers on the different types of leys and the place of the manuring of meadowland in Swedish agriculture are discussed by H. Osvald.*

The relatively small number of investigations hitherto conducted in Sweden regarding the application of artificial manure to different crops show that leys always receive less generous treatment than the other changes in the rotation.

This practice is, however, quite unjustifiable since manurial trials in Sweden have shown unmistakably that the leys well repay quite heavy manuring. In these manurial trials only the increased yield in the first cut was considered ; if the increase in the aftermath, the favourable influence of the manuring on the botanical composition of the ley stand, and the resulting greater value of the ley as a preparatory crop had also been included, the return from the manuring would have been still greater. In the present article attention is confined to the increased amount of hay produced by the manuring.

Phosphoric acid and potash are the two nutrients most necessary to leys in almost every part of Sweden. From an application of phosphate at the rate of 200 kg. per hectare one can generally expect an increase in yield of about 600 kg. hay, except in the parts of Sweden rich in phosphate, such as the lowlands of Scania and of Östergötland. On clover leys the increase in yield is as a rule somewhat greater, on grass leys somewhat less. Potash is usually tested as an application of 40 kg. of 40 per cent potash salts ; it gives a good increase in yield particularly in clover leys. In the majority of cases it appears to be remunerative to apply 100 kg. 40 per cent potash salts to clover leys on clay soils, except those very rich in potash. The average increases in yield have amounted to approximately 400 kg. hay per hectare. Again on other kinds of soil an application of potash is almost always highly remunerative, the average increase in yield being about 800 kg. per hectare. Where grass predominates on leys it is uneconomic to apply potash to clay soil ; on other types of soil it certainly is advisable, as average increases in yield may amount to approximately 600 kg. hay per 100 kg. 40 per cent potash salts. The figures now given for the increased yields resulting from the application of potash explain the increase in the amount of potash used on all clay-free soils to 150 kg. 40 per cent potash salts for grass leys and 200 kg. for clover leys. As, recently, there has been a considerable reduction in the price of potash, farmers are advised to carry out a liberal potassic manuring of their fields.

As long as clover predominates in the meadow stand, nitrogenous manuring is unnecessary, but in older rotation leys in which the stand consists mainly of grasses it is very profitable to apply nitrogen. From an application of 100 kg. 15·5 per cent saltpetre per hectare an increase in yield of 600 to 700 kg. hay can be expected. On leys of the kind just referred to it is frequently remunerative to apply 200 kg. 15·5 per cent saltpetre per hectare. Such a large amount of nitrogen should not be used on a long-duration ley, which, as the result of sowing, or some other procedure, contains white clover in the sward. A liberal nitrogenous manuring of leys of this kind may result in a reduction of the yield, owing to reduced growth of the white clover.

Manuring has also a favourable influence on the botanical and chemical composition of the hay. Phosphate and potash together favour the clover, while nitrogen works in the opposite direction. As it is highly important that the clover should persist as long as possible, the proportions of the different nutrients should of course

*Osvald, Hugo. Om gödsling till vall. [Manuring of leys.] *Svensk Frötidn.* Vol. 4, pp. 27–9. Örebro, 1935.

be adjusted with this object in view, and thus the phosphate-potash manuring should be slightly more liberal than the figures for increases in yield would indicate. The content of useful minerals and of protein in the fodder is increased by the phosphate-potash manuring. Nitrogenous manuring on the contrary does not appear to have any appreciable influence on the protein content of the fodder.

Manuring has further a great influence on the better persistency of the meadow plants in the stand. The phosphate-potash manuring favours not only the clover but also the better fodder grasses, and in districts or on soils where long-duration hay leys are utilized its effect is clearly seen. On such areas, particularly during the early years, timothy is the dominant grass—or at least it should be—but complaints are often heard to the effect that this grass dies out too early. The decline of timothy is in many, possibly in the majority of cases, a question of nutrition. The excellence of a ten-year old timothy ley observed by the author was due to liberal manuring with phosphoric acid, potash, and nitrogen.

At Gisselås, the experiment farm of the Society for the Cultivation of Peat Land in Jämtland, recent manurial trials show very strikingly the dependence of timothy on phosphate-potash manuring. On the sections where the manuring had been adequate and complete, timothy was able to persist ; on other sections where the supply of one of the nutrients had been insufficient the timothy had fallen off markedly, and where one of the nutrients had been omitted altogether, it had disappeared completely at the end of five years. Further, it has been found almost invariably in manurial trials that the ley stands which receive liberal and complete manuring are considerably more cold resistant than the relatively poorly nourished or under-nourished plants.

It may be added that in ley stands where timothy is suppressed as a result of too meagre manuring, its weak condition is always shown first by the fact that it does not develop fertile shoots. The sterile shoots have been formed as fertile shoots, but have not developed owing to lack of vigour of the plant. This result also suggests that in seed production of timothy a good yield can be expected only when the manuring with potash and phosphoric acid has been ample.

A rational manuring of the leys would be of very great importance for Sweden. Assuming that the whole of the grassland area which is used for hay leys received 20 kg. phosphoric acid per hectare—possibly about four times as much as at present ; one-third of the area 40 kg. potash—about three times as much as at present ; and half the area 15 kg. nitrogen—more than five times as much as at present, such a relatively moderate manuring should produce, on the basis of the experimental results available, nearly one and a quarter million tons more hay, containing approximately 475 million food units and 50,000 tons of protein. Sweden would then be quite independent of imported feeding stuffs poor in protein, and even the import of those rich in protein could be reduced considerably. Thus, it is clear that a liberal manuring of Sweden's leys is not only remunerative as far as the individual farmer is concerned, but is also a matter of very great importance from the point of view of national economy.

## THE FODDER PROBLEM IN PALESTINE.

THE report of the Agricultural Adviser to the Secretary of State for the Colonies (Mr. F. A. Stockdale) on his visit to Palestine and Trans-Jordan from March 25 to May 1, 1935, has been published by the Colonial Advisory Council of Agriculture and Animal Health (C.A.C. 247, Colonial Office, October, 1935). All aspects of Palestine agriculture are discussed and recommendations as to improvements are made. The following extracts deal with the fodder problem.

In discussing the dairy industry the report states that the fodder consists largely of concentrated foods produced from imported raw materials, and of green fodder such as berseem (*Trifolium alexandrinum*) and lucerne produced under irrigation. Large crops of lucerne can be raised under irrigation and two strains, Hairy Peruvian and Provence, have proved to be satisfactory. Hay made from a mixed crop of oats and vetch is also largely used ; the production of this crop for the dairy industry has been found to be a remunerative occupation by several important settlements and by some Arab growers. Baling in the field is now practised and portable power baling outfits owned by Jewish settlements are hired by large Arab growers. The cost of production of dairy products is, however, high ; it is recommended that a higher proportion of locally-grown materials should be introduced into the ration.

Little permanent improvement is to be expected with the flocks of sheep and goats until greater attention is paid to feeding. In favourable seasons during the spring months there is adequate grazing available to provide feed for these flocks, but during the summer months and during unfavourable seasons when conditions of drought prevail, there is a very scanty supply of vegetation. Flocks rapidly lose condition and suffer from starvation. Attempts are being made by the Department of Agriculture and Forests to find means for improving the natural pasturage which the waste lands provide, and to raise fodder crops such as vetch and oats for hay or maize for silage. The feeding of concentrates and the use of spineless cactus as a fodder during the height of the dry season should also be encouraged.

The improvement of local cattle also is dependent upon the solution of the fodder problem. It is difficult to persuade owners to change their methods, but propaganda is already producing a change of attitude. The growing of fodder crops such as a mixture of oats and vetch has been widely demonstrated and in some areas results of value have been achieved. A certain interest has been aroused in pit silos ; much improvement in the technique of making silage is still possible.

A section of Mr. Stockdale's report is devoted to a consideration of the whole question of development in the hill area of the country. Progress in the hilly country has not been so rapid as it has been in other parts of Palestine. This is due in part to the natural conditions being difficult, in part to the loss of soil by erosion, and in part to the natural conservatism of the people. Centuries of over-population, overstocking and general lack of attention to the necessity for soil conservation have produced a state of affairs which makes it impossible for the population to obtain anything better than a scanty living. Bare hill-sides are grazed and overgrazed by flocks of sheep and goats on the look out, at certain seasons of the year, for anything having the semblance of a plant residue. During the short growing season, crops of cereals and winter legumes are cultivated on any areas level enough to permit of cultivation. If favourable seasons are experienced, reasonable crops are secured ; but if the rainfall fails, a very scanty living approaching starvation is the lot of both man and beast. Olives, where grown, constitute a crop which is a useful standby, and grape cultivation, where possible, gives reasonably certain returns. In order to improve the lot of the farmers in the hill villages, it is necessary to widen their agricultural activities, and to this problem the Government of Palestine and its Department of Agriculture are giving attention. It is clear that efforts to improve animal husbandry should be attempted, but it must be recognized that this work is

likely to have little permanent value unless the food for the animals can be improved. Little can be accomplished on the natural grazing of the hill slopes unless rotational systems of grazing can be introduced and certain areas are set aside for afforestation with the object of water conservation. Attempts are being made to introduce and establish exotic pasture grasses, but experience elsewhere indicates that improvement by this means may be difficult to secure. The Australian and English grasses which so far have been tried have shown promise under the favourable conditions of the wet spring of 1935, but it is expected that they will die out completely during the drought of the summer months. Grasses with stoloniferous root systems alone are likely to withstand the severe conditions of the Palestinian summer on the hill slopes of the central range, and trials with some of the South African grasses which have been specially selected from areas where severe droughts are experienced would appear to be advisable. Strains of the woolly finger grass (*Digitaria* sp.) which have been collected and tested by Dr. Pole Evans at Pretoria might be worthy of a trial. Subterranean clover (*Trifolium subterraneum*), by which Australian pastures have been so improved in recent years, has been tried in several areas. It shows considerable promise and has readily become established in certain hill areas during the past season. It is by means of deep-rooting leguminous plants that improvement of the pasturage of the hill slopes is most likely to be effected, and the progress made by subterranean clover this year would appear to warrant further extended trials.

Other leguminous plants worthy of trial would be the Japanese Kudzu vine (*Pueraria thunbergiana*), certain strains of lucerne from dry areas in the Middle East, and possibly *Indigofera endecaphylla*.

Whilst a certain amount of improvement can be effected by the introduction of exotics, it is to be expected that the greatest benfit is likely to accrue from the encouragement of certain plants of the natural herbage. A careful botanical study of the existing herbage, with a view to securing data on the seasonal growth of the several plants which make up its composition, seems to be indicated, and determined efforts to establish rotational grazing should be made. There are several areas throughout the country which clearly show how a natural herbage and even shrub growth will result where fencing of the area is provided, and there is little doubt that by the adoption of a system of rotational grazing the carrying capacity of the hill slopes for small stock could be greatly increased. The planting of carobs in the hilly areas is also to be strongly advocated, since the carob fruit provides an animal food of a high value, and, as has already been indicated, extended trials of the spineless cactus would appear to be warranted.

## LUCERNE AND PASTURES IN ARGENTINA.

In the period from mid-November, 1934, to mid-June, 1935, the Deputy-Director of Agriculture in South Australia (W. J. Spafford) made a tour embracing portions of New Zealand, Chile, Argentina, Uruguay, Southern Brazil and South Africa, and recorded the agricultural conditions, industries, and practices. These particular countries were selected because of their location in the same climatic zones as the settled portions of Australia, i.e. where the climatic conditions are either temperate or sub-tropical. The reports of this tour have been appearing in the *J. Dept. Agric. S. Australia* (Vol. 39, Nos. 2, 3, 4, and 5, 1935), while an abstract of the series has appeared in *J. Aust. Inst. Agric. Sci.*, 1, 143–5, 1935.

The present review concerns that part of the report which deals with Argentina (pp. 350–87 and 485–524). The opening sections deal with the country, the agricultural plain of Argentina, and its climate (rainfall and temperatures). The land of Argentina is utilized as follows :

| | Area in acres | Percentage |
|---|---|---|
| Under cultivation .. .. .. .. .. .. .. | 74,175,000 | 10·75 |
| Grazed by livestock .. .. .. .. .. .. | 306,636,000 | 44·44 |
| Forests and woods .. .. .. .. .. .. | 123,648,000 | 17·92 |
| Desert, towns, mountains, lakes, and rivers .. .. .. | 185,541,000 | 26·89 |
| Total land in Argentina .. .. .. .. .. | 690,000,000 | 100·00 |

In 1933–34 the areas (in acres) under the principal crops were : wheat 19,654,531, maize 16,589,580, lucerne 13,353,907, followed by linseed (with 6,850,619) oats, barley and rye.

### Lucerne.

Lucerne is by far the most important pasture plant ; its high nutritive value and protein content make it an excellent fodder for the large number of grazing animals, and it is so vigorous and hardy that it can compete reasonably well with the prolific weeds which grow in such rich country. The conditions are ideal for the cultivation of this crop ; a rich silt one to two feet or more in depth, resting on subsoils sufficiently open to prevent waterlogging and to permit root penetration, together with a rainfall of 25 to 50 inches, 30 per cent of which falls in each of the three-month growing periods of spring, summer and autumn. The fairly high temperatures during the rainy part of the year also favour growth. Where the underground water table is within the reach of the lucerne roots the crop is even more vigorous. When well managed an average of six cuts a year is obtained, while some fields may give as many as ten. Good lucerne land carries a Friesian cow per hectare, as well as rearing all calves.

The methods of establishing the lucerne crop vary considerably ; seven different methods are described by Mr. Spafford. Although these older methods gave reasonably good results, it is being realized that more care is now necessary on land carrying lucerne for a long period of time and quite good soil preparation is being given in some cases. The deterioration of the lucerne crop is due to weed contamination, poor methods of cultivation, lack of manure and overgrazing ; probably the lack of lime and phosphorus is the most important factor.

Large quantities of lucerne are stored as hay or as silage ; in the latter case the fodder is almost invariably stored in stacks built on the surface of the ground, or possibly in shallow pits about two feet deep.

### CEREALS.

After lucerne, rye and oats are probably the most important grazing plants in Argentina. One or other, seldom a mixture, is sown in the early autumn (late February or March) and is generally grazed as soon as there is sufficient growth. Cattle-men prefer to use rye in autumn and early winter and oats in late winter and early spring. No fertilizer is added at sowing. The cereal crops are frequently grazed down very heavily in the spring and the land is then cultivated and sown to a summer-growing fodder crop.

### OTHER FORAGE AND PASTURE PLANTS.

Forage sorghum and Sudan grass are becoming popular summer forage crops, as cattle fatten very quickly on either if allowed access to a lucerne field at the same time. The crop is sown in spring, and is grazed down close when in head in the autumn ; the land may then be ploughed and seeded to rye or oats for winter feeding. Sorghum and Sudan grass are good smother-crops for controlling *Cynodon dactylon*.

*Chloris gayana* (Rhodes grass) is giving good results in the north, where the climate is definitely sub-tropical. Other plants of minor importance are *Cynodon dactylon* (difficult to eradicate when re-establishing lucerne), *Bromus unioloides*, *Paspalum dilatatum*, *P. notatum*, *Andropogon halepense* (becoming a serious pest) and *Trifolium repens* (probably to be of great value in the future). The good pasture lands have few leguminous plants other than lucerne. This defect of sub-tropical lands has been overcome in Argentina by the success and general use of lucerne ; in certain restricted areas *Medicago denticulata* appears to grow strongly.

# CONFERENCES

**UNITED STATES OF AMERICA.**

The American Association for the Advancement of Science (Smithsonian Institution Building, Washington, D.C.) have published (1934) their "Summarized Proceedings, June, 1929 to January, 1934," Volumes 82 to 86. The following extracts from the preface will explain the scope of this publication :

"The American Association for the Advancement of Science during its earlier years, and up to 1900, published annual volumes of Proceedings. In that year was concluded the arrangement by which *Science* became the official organ of the Society. By its appearance weekly, *Science* has afforded prompt publication as well as more extended accounts of meetings than were appropriate in an annual volume. The change was in every way desirable, and *Science* has played an important part in the growth of the Association and in maintaining vital contacts with the large and widely distributed membership. This journal now devotes one of its weekly numbers, largely, if not entirely, to each of the meetings of the Association, and also gives wide publicity to announcements and notices of importance concerning the work of the Association and its affiliated societies.

"This movement, while it naturally modified the character of the volume previously issued, did not do away with the need for a periodic historical record. These Summarized Proceedings discharge that function. Issued at intervals of three to five years they furnish a succinct account of the organization and membership of the Association, including data not otherwise available.

"In the main this volume follows the style and contents of previous issues with a few changes in minor details in the effort to attain greater accuracy and convenience in use. Two major features deserve brief mention. The first is a valuable study of early American scientific organizations and the inter-relations out of which sprang the American Association for the Advancement of Science. It replaces the accounts of the history and of the organization of the Association which have appeared in earlier volumes. The second is a geographical index of the membership, which has been prepared and published here for the first time in this series. It emphasizes the degree to which the Association has extended its influence over the length and breadth of our country."

**PRAGUE, 1935.**

Information regarding the March session of the Czechoslovakian Academy of Agriculture is available from two articles published in Czech journals.

In *Agricultural Topics* of the Czechoslovak. Acad. Agric. No. 49, p. 276 (German summary, pp. 265–72), 1935, edited by F. Chmelař and A. Klečka, twenty-seven detailed reports are included.

In the introductory lecture, Professor F. Chmelař dealt with the tendencies and problems of modern forage production. F. Svoboda presented methods of planning in the nutrition of domestic animals, and Professor K. Holý lectured on the principles of his evaluation of proteinous feeding stuffs. Several lectures were devoted to the improvement of production and conservation of forage (on such subjects as legumes, field forage crops, mixtures, meadows and pastures, their fertilization, irrigation, breeding, etc.). K. Mostovoj prepared a review of new forage crops. L. Brada

lectured on the problems of grass seed production, and E. Baudyš on the damage caused by diseases on forage crops. O. Horak, F. Lom, and A. Klečka presented their plan for the organization of forage production in the different regions (such as the sugar beet region, cereal region, etc.; see *Herb. Publ. Ser. Bull.* 15, p. 32).

The same authors (A. Klečka and F. Chmelař) prepared a summary of these reports, which was published in the *Bull. Czech. Acad. Agric.*, Vol. 11, pp. 531–5, 1935. They discuss the causes of the present tendencies in forage crop production (such as the reduction in cereal area, price regulation of commercial foodstuffs, etc.), the possibilities of increasing home forage production, improvement of quality of forage, etc. They deal with the necessary meadow and pasture improvement, changes in growing of field legumes, seed production, rotation, etc., and emphasize the necessity for irrigation. The measures necessary for the further improvement of forage production are summarized in twelve points:

(1) Higher prices of commercial concentrates.
(2) Production of first quality seed of legumes and the breeding of these plants.
(3) Withdrawal of advantages for imported maize seed.
(4) Furthering of clover and lucerne seed production.
(5) Imposition of a protective duty on foreign grass seed.
(6) Necessity for an all-state irrigation programme.
(7) Organized propaganda for mountain meadow and pasture improvement.
(8) Obligatory abolition of fallowing.
(9) Financial support for these measures from the Ministry of Agriculture.
(10) Foundation of two to three stations for the study and breeding of forage crops.
(11) Advertising of standard silage types and methods of conservation.
(12) Establishment of a meadow-pasture foundation for improvement of grassland.

—F. Ch.

**PAARL, 1935.**

The South African Association for the Advancement of Science met at Paarl (Cape Province) from July 1 to 6, 1935, under the Presidency of Professor M. M. Rindl, Professor of Organic Chemistry, University College of the Orange Free State (formerly Grey University College). The Presidential Address delivered on July 1 was on the following topic: "A plea for the establishment of a National Research Council and for the initiation of a national research policy in South Africa." Among the papers read to the meeting were the following (published in Vol. 32 of *South African Journal of Science*):

Phillips, E. P. The rôle of plant taxonomy in science (37–48).
Rimington, C., and Steyn, Douw G. The isolation of a new bitter principle from a South-west African species of *Cucumis*. (137–41.)
———— and Quin, J. I. The isolation of an icterogenic principle from *Lippia rehmanni*, Pears. (142–51.)
———— Chemical investigation of the "gifblaar" *Dichapetalum cymosum* (Hook) Engl. (152–3.)
———— The chemical constitution of acacipetalin, a new cyanogenetic glucoside isolated from *Acacia lasiopetala*, Oliv. and *Acacia stolonifera*, Burch. (154–71.)
Hall, T. D., and Murray, S. M. The botanical analysis of intensively grazed pastures. (189–96.)
———— Moses, D., and Murray, S. M. The botanical composition of exotic pastures in South Africa. (197–204.)
———— Intensive grazing on veld-III. The rôle of intensive management in wool production in the Eastern Transvaal. (205–22.)
Henrici, M. Germination of Karroo bush seeds. (223–34.)
Barenbrug, T. H. Veld improvement. Seed production. Seed testing. (257–67.)
Pullen, A. R. New varieties of teff, *Eragrostis tef* (Zucc) Trotter. (268–70.)
Mes, M. G., and Aymer-Ainslie, K. M. Studies on the water relations of grasses, 1. *Themeda triandra*, Forsk. (280–304.)
Dyer, R. A. The seed germination of certain species of *Euphorbia*. (313–9.)
Smit, B. *Lentula obtusifrons* Stal., the beneficial Rhenosterbos locust. (461–8.)

**LONDON, 1935.**

A section of the Third Imperial Botanical Conference which was held in the rooms of the Linnean Society of London, Burlington House, from August 28 to 30 was devoted to "Pasture Research in Different Parts of the Empire." The report of this Conference is now available from the Royal Botanic Gardens, Kew, price one shilling.

The following papers were contributed on the subject of pasture research :

Stapledon, R. G. The importance of strain in grassland plants.
Evans, I B. Pole. Pasture research in South Africa.
Scarth, G. W., and Whyte, J. H. Pasture research in Eastern Canada.
Blackman, G. E. The influence of nitrogen supply and other factors on the growth of pasture plants.
Jones, M. G. The influence of the biotic factor on the growth of pasture plants.

These papers are summarized on pp. 11 to 13 of the report. The article by Dr. I. B. Pole Evans will be published in Bulletin 18 of the Herbage Publication Series on "Grasslands and Forage Crops in South Africa," at present in preparation. The articles by G. E. Blackman and M. G. Jones are abstracted in Jealott's Hill Bulletin, Vol. 4, No. 8, p. A125, 1935.

**CHICAGO, 1935.**

The Presidential Address delivered by H. K. Hayes, Chief of the Division of Agronomy and Plant Genetics, University of Minnesota, St. Paul, Minnesota, before the 28th Annual Meeting of the American Society of Agronomy, held in Chicago on December 5, 1935, is published under the title of "Green Pastures for the Plant Breeder," in the Journal of the Society (27, 957–62, 1935). The following paragraphs are extracts from the section devoted to the improvement of grasses and forage crops :

"With many crop plants much less has been accomplished in crop improvement than with maize and wheat and with some crop plants, particularly the grasses, studies of improvement have not progressed very far. As one investigator stated the problem, the grass plants are in much the same condition as would result if all wheat varieties were mixed together and grown as a single crop without varietal separation. We should not overlook the fact that some countries of the world have made a good start in grass improvement, notably Wales, Sweden and Canada. Our own country lags far behind, although there is much evidence of renewed interest in grasses and forage crops. A greater acreage in these classes of crops is recommended by agronomists and others for the future for many regions of United States in connexion with the agricultural planning studies that have been made this last summer. Efficiency of production demands efficient varieties.

"At present, methods of breeding grasses and forage crops have not been standardized. The necessary information for such standardization is not available and certainly all grasses cannot be handled by the same breeding method. There is a serious lack of such essential information as mode of pollination, extent of self-sterility, and relative desirability in grasses of self-fertility or sterility. It is evident that many grasses are mixtures of self-fertile and self-sterile lines. With red clover, for example, where formerly it was considered that cross fertilization was necessary to seed production, it is now known that highly self-fertile lines can be selected. By genetic methods it should be easy to combine self-fertility with other characters if that is desirable.

"With timothy, some breeders in America have concluded that self-fertilization and selection was a logical method of improvement. Several foreign workers state that timothy is highly self-sterile and that self-fertile and vital lines are so infrequent that self-fertilization and selection are not logical methods of improvement.

"At a conference on alfalfa improvement in Washington, there was a wide divergence of views regarding the extent to which self-fertilization could be used as a logical tool in alfalfa improvement. The probable effects of self-fertilization and selection with each of the grasses and forage crops should be made known.

"All that was emphasized (earlier in the address) regarding the value of an intensive knowledge of differential characters with corn and wheat is of equal importance in grass and forage crop improvement. The returns from such intensive studies of grass and forage crop improvement would, I am sure, yield a handsome dividend, based on the cost of the research. Several trained investigators in nearly every State of our Union could find pleasant and profitable employment in grass and forage crop improvement. It is our privilege as agronomists to emphasize the importance of fundamental research as a means of developing efficiency in agriculture."

**ABERYSTWYTH, 1937.**

The Fourth International Grassland Congress is to be held in Great Britain in 1937, under the Presidency of Professor R. G. Stapledon, C.B.E., M.A., Director of the Welsh Plant Breeding Station, and of the Imperial Bureau of Plant Genetics : Herbage Plants, Aberystwyth.

The congress is the fourth of a series which has been arranged for the meeting of specialists in grassland research and management from a number of countries.

The 1937 congress will be more extensive than the third of the series, which was held at Zürich, Switzerland, in 1934, in so much as specialists from the British Dominions and Colonies, the United States of America, and numerous other countries are being invited to take this opportunity of meeting prominent British and European investigators.

According to present plan, the paper-reading sessions of the fourth congress will be held at Aberystwyth on July 15 to 18, 1937 (enrolment on July 14). Intending participants will be invited to join in a tour of centres of grassland interest both before and after these sessions. The tour will be made partly by motor coach and partly by rail. It will be possible to choose one of the four following options :—

| | *July* |
|---|---|
| (1) Attending paper-reading sessions and local Aberystwyth tours only .. .. .. .. .. .. .. | 14–18 |
| (2) Assembling at Oxford, proceeding via selected centres of grassland interest to Aberystwyth and participating in sessions and local tours .. .. .. .. .. | 8–18 |
| (3) Attending paper-reading sessions and local tours and proceeding from Aberystwyth to Newcastle and Edinburgh, where disperse .. .. .. .. .. .. | 14–23 |
| (4) Assembling at Oxford, proceeding to Aberystwyth, attending paper-reading sessions and local tours and proceeding thence to Edinburgh .. .. .. .. .. .. .. | 8–23 |

It is early yet to give any approximation of cost, but it is expected that the all-in charge for the whole congress, including accommodation and transport (i.e. option 4), will be of the order of £20. Intending participants under option (1) will be expected to pay a congress fee and to find their own accommodation. A list of approved hotels, etc., in Aberystwyth and neighbourhood can be obtained from the Secretaries.

The paper-reading sessions have been tentatively arranged to cover the following subjects ; this classification will be adjusted to suit later requirements.

(1) Ecology (including surveys), pasture management (including erosion control).
(2) Seeds mixtures (including lucerne for grazing) ; legumes for use in poor pastures.
(3) Plant breeding, genetics, and seed production.
(4) Manures and fertilizers.
(5) Fodder conservation.
(6) Grassland economics.

It is important that the Secretaries should receive at least a tentative notification of intention to attend the congress from those who wish to do so. Such tentative notification will be welcomed as soon as possible ; some indication as to choice of option will also be of great assistance in the planning of the congress. As soon as the financial details relative to the tours have been settled, and other arrangements completed, further information in the form of brochure and acceptance form will be circulated. These will then need to be completed before a date which will be specified later.

With reference to papers to be read at the congress, the British Executive Committee have decided that it is desirable that the main papers shall be read at plenary sessions. Such papers will necessarily be limited in number, and will be by invitation. Additional papers will be read in sectional meetings. It is therefore desirable to limit the number as far as possible. It would facilitate the arrangements if those who desire to read papers would inform the Secretaries, giving title and language to be used, when notifying their intention to attend. The Secretaries will also be glad to receive addresses of persons to whom this notice might be sent.

All correspondence to be addressed to :—

JOINT SECRETARIES,
Fourth International Grassland Congress,
Agricultural Buildings,
Aberystwyth, Great Britain.

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**Will Journals please copy this preliminary notice of the Fourth International Grassland Congress?**

# ANNOTATIONS

## HOLLAND. (492)

The report of the State Agricultural Experiment Station for Arable and Grassland Cultivation, Groningen, for the year 1934 ('s-Gravenhage, Departement van Landbouw en Visscherij, 1935, pp. 16) contains sections on grassland research.

*Field Trials.*—Of the 99 field trials of varying duration, 15 were concerned with grassland and dealt respectively with N in relation to pH values, with liming, the application of NP, time of mowing, manurial treatment, and miscellaneous problems.

*Plot Trials.*—During the year under review, an experiment was laid down to test the behaviour of 12 grass species and of white clover, grown separately and also in five different mixtures, in soil of six different pH values. The experiment promises to be instructive.

*Technique of Grassland Trials.*—Results of a study of this subject have already been published. (See Frankena, *Herb. Abstr.* 6. 28. 1936.)

*Evaporation of Sward.*—The material was composed of sods of nine different grass species, sods from the same field with no plant cover, and water surface. There was a certain amount of difference between the different grass species ; evaporation from the sward was on an average always somewhat less than that from the water surface, but almost twice as great as that from the sods without vegetation.

*Study of Root System.*—This has been pursued in relation to the effects of manurial treatment, with special reference to phosphates.

*Vernalization.*—Experiments have been conducted with winter and summer varieties of cereals. Little or no result is recorded in the case of the latter, greatly accelerated development and earlier flowering the case of the former.

*Botanical Analysis of Grass Samples.*—Samples numbering 305 have been dealt with during the year under review.

*Technique* of *Grassland Analysis.*—An experiment is in progress to test the reliability (mean error) of the botanical analysis of small plots ($\frac{1}{2}$ are) on old grassland of three different soil types. The results of a comparative study made in the previous year are being summarized, and in continuation thereof a comparison of the frequency method with the weight analysis method is being made this year in different localities.

*Grassland trials* have been concerned in the main with the effect of nitrogenous fertilizers in conjunction with different times of mowing, etc., and with the quantity and form in which N is applied. These trials have necessitated the use of 285 trial fields and the study of approximately 2,000 harvests. Four NP trials are still in progress.

*Chemical Composition of Grass.*—The study of individual grasses grown in 1932 and 1933 has been completed. The influence of nitrogenous fertilizers upon the chemical composition of different species has been studied, and the analysis of individual grasses selected from grassland ready for mowing has been initiated.

*Weeds.*—The study of weeds has included a consideration of their competitive ability under varying pH conditions.

*Inoculation of Legumes.*—The preparation of inoculants for lucerne, lupins, serradella, and vetch has been continued, the demand for lucerne inoculants in particular having increased. In the case of some soybean varieties inoculants proved ineffective, for which reason twelve strains of bacteria from America and Germany have been tested for their virulence in regard to the various strains, wherein specific differences appear to exist. The advisability of using mixed cultures is being studied.

A list of publications by members of the staff is appended.—G.M.R.

## RUMANIA. (498)

An article by N. Saulescu on the Plant Breeding and Seed Control Station at Cluj, Rumania, has been published in *Züchter*, 7. 19–23. 1935. This station includes the Plant Breeding Station proper, founded 1929–30, the Seed Control Station, founded in 1884, and the Station for Medicinal Plants, founded in 1904. The first two departments were housed together in a new building in 1933.

Herbage plant breeding consists in the selection, reproduction and testing of élite plants from indigenous populations, the material being clover, lucerne, *Lolium perenne*, *Festuca rubra*, *Phleum pratense* and *Avena elatior*. The herbage plant gardens at Cluj comprise from 800 to 1,000 plots of approximately 1 hectare, and experiment fields in other parts of the country are also available. Valuable strains have been obtained and are at present being reproduced.

The Seed Control Station employs the methods laid down by the International Regulations and seals all such seed as fulfils legal requirements. Largely owing to the strict supervision exercised, especially in regard to *Cuscuta* content, the Siebenbürg (Transylvanian) red clover enjoys a high reputation abroad. Special methods used in the testing of grass, clover and lucerne seeds are noted. In addition, the Station is carrying out experimental work with *Cuscuta*, sowing the latter at various depths and at various distances from the host plant, and testing different methods of control.—G.M.R.

## SOUTHERN RHODESIA. (689.1)

The Director of the Department of Agriculture of Southern Rhodesia is perturbed by certain references which have appeared (*Herb. Abstr.* 2. 249. 1932, and 3. 234. 1933) regarding the desirability of the leguminous shrub, *Leucaena glauca*, as a browsing crop for livestock. A brief note on the value of this plant in Southern Rhodesia appears in the *Rhodesia Agricultural Journal*, 33, 83–4, 1936. Any readers who have experience with this plant, particularly in connexion with its reported depilatory effect on animals such as horses and pigs, are requested to communicate with the Chief Officer of the Herbage Bureau immediately. The Department in Southern Rhodesia is naturally anxious to clear up the question as soon as possible, and in the meantime has advised farmers to eliminate the plant from the ration of cows and sows.

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**Chronica Botanica, the year-book of plant science,** has been designed to bring together the research programmes of all laboratories, experimental stations, herbaria, botanic gardens, etc., to give a résumé every April of the professional and personal news of the past year and to promote co-operation between workers in the various branches of plant science in every possible way.

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